

Fixed Ground Antenna Radome (FGAR) Type I/III OT&E Integration and OT&E Operational Final Test Report

Leonard H. Baker



May 1995

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| 16. Abstract <p>This test report documents the Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing performed on the Type I/III, Fixed Ground Antenna Radome (FGAR). The Type I/III FGAR is used with the Air Route Surveillance Radar (ARSR) -1/2 and AN/FPS military radars.</p> <p>The testing was performed at the Federal Aviation Administration (FAA) Technical Center's Elwood En Route Beacon Test Facility (ERBTF) and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado. The testing included: (1) characterization of the primary and secondary radar's electromagnetic performance, (2) human factors, (3) physical characteristics, and (4) physical performance.</p> <p>The electromagnetic performance testing showed no degradation of the primary or secondary radars; there were no human factor problems found; and only minor problems were identified during the physical characteristics and physical performance tests. The testing determined that the FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA.</p> | | | |
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EXECUTIVE SUMMARY

Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing of the Type I/III Fixed Ground Antenna Radomes (FGAR) was performed at the Federal Aviation Administration (FAA) Technical Center's En Route Beacon Test Facility (ERBTF), Elwood, New Jersey (NJ), and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado (CO). Testing at the Elwood ERBTF was performed during the period August 15 to December 6, 1994. Testing at the Trinidad En Route Radar Facility was performed during the period October 3 to November 25, 1994.

FGAR OT&E Integration and OT&E Operational testing included: (1) characterization of the primary and secondary radar's electromagnetic performance, (2) human factors, (3) physical characteristics, and (4) physical performance.

Electromagnetic performance testing was accomplished in several ways: (1) comparative measurements were made between the original inflatable radome and the FGAR using the Mode Select Beacon System (Mode S) at the Technical Center's Elwood ERBTF, (2) the Northwest Mountain Region's Radio Frequency (RF) Interference Monitoring (RFIM) van was used to make comparative horizontal and vertical solar measurements between the original radome and the FGAR, (3) the Albuquerque (ZAB) and Denver (ZDV) Air Route Traffic Control Center's (ARTCC) compared Trinidad En Route Radar Facility (TAD) data received before and after the FGAR was installed, and (4) Air Traffic Control Specialists (ATCS) at the Albuquerque (ZAB) and Denver (ZDV) ARTCCs evaluated the Trinidad En Route Radar Facility (TAD) video data on their displays. In addition, the Northwest Mountain Region's Establishment Engineering Branch, ANM-450, had a flight check performed.

Human factor tests verified that the access hatches did not present a constraint to individuals wearing heavy winter clothing and there were no electrical hazards. The physical characteristics tests verified nameplates and labels were present on the radome and its subassemblies. The physical performance tests verified there was adequate transient protection provided to prevent transients from entering the facility electrical or signal systems.

The electromagnetic performance testing showed no primary or secondary radar electromagnetic performance degradation; there were no human factor problems found; and only minor problems identified during the physical characteristics and physical performance tests. These problems should not delay deployment of the FGAR, but should be corrected during production or installation, as appropriate.

In conclusion, OT&E testing determined that the FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA. The FGAR is ready to be integrated into the National Airspace System (NAS).

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this report is to provide the results of the Operational Test and Evaluation (OT&E) Integration and Operational testing accomplished on the Type I/III Fixed Ground Antenna Radomes (FGAR) installed, at the Federal Aviation Administration (FAA) Technical Center's Elwood, New Jersey (NJ) En Route Beacon Test Facility (ERBTF) and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado (CO), both of which are considered to be First Article sites.

1.2 SCOPE.

OT&E testing was conducted at two locations: the Technical Center's Elwood ERBTF was selected because it had an En Route Mode Select Beacon System (Mode S) and the Northwest Region's Trinidad En Route Radar Facility (TAD) because it was a National Airspace System (NAS) regional facility with operational interfaces and environmental conditions that allowed the completion of OT&E testing on the first subsystem prior to the Deployment Readiness Review (DRR) deployment decision.

The Northwest Mountain Region's Establishment Engineering Branch, ANM-450, scheduled a flight check of the Trinidad En Route Radar Facility (TAD). The results of the flight check are included in this report.

The following tests were performed:

a. Electromagnetic performance.

1. Elwood ERBTF.

Utilizing the En Route Mode S, Air Route Surveillance Radar (ARSR) -2, AN/UPX-27 Beacon System, and Common Digitizer (CD) -2.

2. Trinidad En Route Radar Facility (TAD).

(a) Utilizing the Air Traffic Control Beacon Interrogator (ATCBI) -3, ARSR-2, and CD-2.

(b) Albuquerque (ZAB) and Denver (ZDV) Air Route Traffic Control Center (ARTCC) Quick Analysis of Radar Sites (QARS) program analysis.

(c) Albuquerque ARTCC (ZAB) Range, Azimuth, Radar Reinforcement Evaluator (RARRE), Beacon False Target Analysis (BFTA), and Common Digitizer Data Reduction (COMDIG) programs analysis.

(d) Albuquerque (ZAB) and Denver (ZDV) ARTCC Air Traffic Control Specialist (ATCS) evaluation.

(e) Aircraft flight check.

b. Human engineering.

c. Physical characteristics.

d. Physical performance.

2. REFERENCE DOCUMENTS.

2.1 FAA ORDERS.

| | |
|-------------------|--|
| Order 6050.32 | Spectrum Management Regulations and Procedures Manual |
| Order 6100.1C | Maintenance of NAS En Route Stage A - Air Traffic Control System |
| Order 6365.3 | Maintenance of the Mode Select (Mode S) Beacon System |
| Order OA P 8200.1 | United States Standard Flight Inspection Manual |

2.2 FAA SPECIFICATIONS.

| | |
|-------------|--|
| FAA-E-2716 | Mode Select Beacon System (Mode S) Sensor |
| FAA-E-2773b | Fixed Ground Antenna Radome (Mode S Compatible) |
| FAA-E-2835 | Environmental Remote Monitoring Subsystem (ERMS) |

2.3 OTHER FAA DOCUMENTS.

| | |
|--------------------|---|
| FAA-4306B-6H | User's Manual - Common Digitizer Data Reduction (COMDIG) Program |
| FAA-4306F-3H | User's Manual - Common Digitizer Record (CD Record) Program |
| FAA-4306M-6H | User's Manual - Range, Azimuth, Radar Reinforcement Evaluator (RARRE) Program |
| FAA-4306N-7H | User's Manual - Quick Analysis of Radar Sites (QARS) Program |
| FAA-4306P-9H | User's Manual Beacon False Target Analysis (BFTA) Program |
| SPB-TRA-009 | New Radar Analysis Software for the Transportable Radar Analysis Computer System |
| DOT/FAA/CT-TN93/17 | Test and Evaluation Master Plan (TEMP) for Fixed Ground Antenna Radomes (FGAR) |
| DOT/FAA/CT-TN94/63 | Operational Test and Evaluation (OT&E) Integration and Operational Test Plan for Fixed Ground Antenna Radome (FGAR) |
| DOT/FAA/CT-TN94/65 | Operational Test and Evaluation (OT&E) Integration and Operational Test Procedures for Fixed Ground Antenna Radome (FGAR) |

2.4 FAA FIELD TEST REPORTS.

ATCS Evaluation Questionnaire, FGAR OT&E Operational Test, Form FGAR-2AB. Questionnaires completed by Air Traffic Control Specialists (ATCS) at the Albuquerque ARTCC (ZAB), Undated

Leone, Andrew, ACW-100B "REPORT - FGAR Mode S OT&E Testing at the Technical Center's Elwood ERBTF." Report prepared for Associate Program Manager for Test (APMT), ACW-100B, January 31, 1995

Manager, Albuquerque ARTCC AFS (ZAB) "Trinidad (TAD) Long Range Radar Radome Replacement Evaluation." Report prepared for Associate Program Manager for Test (APMT), ACW-100B, December 8, 1994

Manager, Denver ARTCC (ZDV) "Trinidad Radar Questionnaire" Memorandum to Air Traffic Manager, ANM-500, January 5, 1995

Manager, Denver ARTCC AFS (ZDV) "Evaluation of Radar Data From Trinidad, CO, ARSR." Report prepared for Associate Manager for Test (APMT), ACW-100B, December 22, 1994

Ulm, Jim, ANM-464I "Radome Replacement Tests, Trinidad, Colorado." Report prepared for Manager, ANM-464, Technical Support Section, Northwest Mountain Region, November 11, 1994

Ulm, Jim, ANM-464I "Radome Replacement Tests, Trinidad, Colorado." Report prepared for Manager, ANM-464, Technical Support Section, Northwest Mountain Region, March 29, 1995

Walsh, Steve, ANM-450E3 "Flight Check Report - Trinidad, Colorado, ARSR-2, ATCBI-3." Report undated

2.5 U.S. GEOLOGICAL SURVEY (USGS) MAPS.

Lockwood Arroyo Quadrangle, Las Animas County, Colorado, Scale 1:24,000, 7.5 Minute Series (Topographic), 1972 (Photorevised 1984)

Thatcher Quadrangle, Las Animas County, Colorado, Scale 1:24,000, 7.5 Minute Series (Topographic), 1970

3. SYSTEM DESCRIPTION.

3.1 MISSION REVIEW.

The FAA program to implement the En Route Mode S resulted in a requirement to replace the existing radomes at en route radar and beacon-only-site (BOS) facilities. The existing radomes are not physically large enough to accommodate the En Route Mode S back-to-back antennas. The FGAR supplies optimal protection of the antennas from the outside environment while providing minimal degradation to the electromagnetic performance characteristics of the enclosed antennas.

3.2 TEST SYSTEM CONFIGURATION.

The Type I/III FGAR provides an optimal environmental enclosure for a collocated L-band surveillance radar reflector and top-mounted back-to-back L-band beacon phased array antennas. The radome is capable of withstanding wind velocities of 150 miles per hour (MPH). They have an inside diameter of 59 feet at their widest point, and will fit a base ring diameter equal to the present CW-396A radome. The Type I/III FGAR is used with the ARSR-1/2 and AN/FPS-type surveillance radars.

The radome is supplied as a complete assembly, which includes:

- a. Lightning protection subsystem (LPS).
- b. Zenith Service and Catwalk Access Hatches.
- c. Aircraft obstruction light (AOL) assembly.

- d. Devices to monitor the state of the AOLs and the access hatches condition (open/closed).

3.3 INTERFACES.

The Type I/III FGAR interfaces both mechanically and electrically with NASs. A block diagram of the interfaces is shown in figure 3.3-1.

3.3.1 Mechanical.

The Type I/III FGAR interfaces mechanically with the existing antenna tower radome base ring.

3.3.2 Electrical.

The Type I/III FGAR interfaces electrically with the antenna tower/facility:

- a. Electrical system
- b. LPS
- c. Remote Maintenance Monitoring System (RMMS)/Environmental Remote Monitoring Subsystem (ERMS)

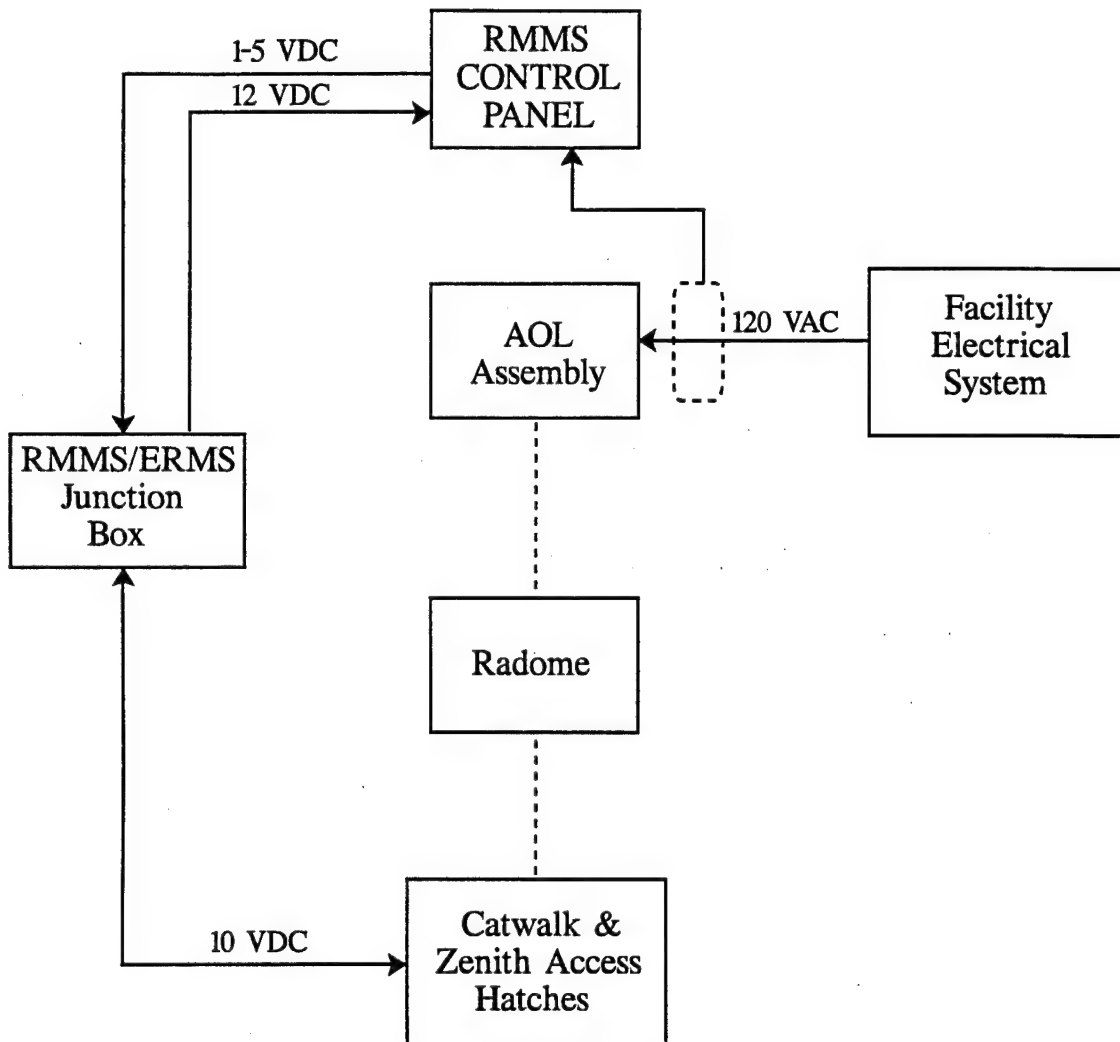
3.3.3 Interface Testing.

a. Mechanical.

The mechanical interface between the FGAR antenna tower/CW-396A radome base ring was completely tested during on-site Design Qualification Test (DQT) testing.

b. Electrical.

1. The interface between the FGAR and the facility electrical system was completely tested.
2. The interface between the FGAR and the antenna tower LPS was completely tested during on-site DQT testing.
3. The interface between the FGAR and the RMMS/ERMS could not be tested, since the ERMS has not been developed yet. The FGAR side of the interface, however, was tested against the requirements of specification FAA-E-2835.



LEGEND

- Mechanical
- ===== Electrical
- Inductive Coupling

FIGURE 3.3-1 FGAR INTERFACES BLOCK DIAGRAM

4. TEST AND EVALUATION DESCRIPTION.

4.1 TEST SCHEDULE AND LOCATIONS.

a. Elwood ERBTF.

Testing at the Technical Center's Elwood ERBTF was performed during the period of August 15 to December 6, 1994.

b. Trinidad En Route Radar Facility (TAD).

Testing at the Trinidad En Route Radar Facility (TAD) was performed during the period of October 3 to November 25, 1994.

4.2 PARTICIPANTS.

The test participants included personnel from a several different organizations and contractors (appendix A contains a list of the individual test participants). The organizations and contractors participating were:

- a. En Route Radar Engineering Division, ANR-800
- b. Secondary Surveillance Systems Division, ACW-100
- c. Maintenance Engineering Branch, ANM-464
- d. Albuquerque ARTCC (ZAB)
- e. Albuquerque ARTCC (ZAB) Airway Facilities Sector (AFS)
- f. Denver ARTCC (ZDV)
- g. Denver ARTCC (ZDV) AFS
- h. MiTech/ACW-100B
- i. Raytheon/ACW-100B
- j. Vitro/En Route Surveillance Radar, ANR-400
- k. Electronic Space Systems Corporation (ESSCO)

4.3 TEST AND SPECIALIZED EQUIPMENT.

The following Government furnished equipment (GFE) was used to perform the tests:

a. Elwood ERBTF.

- 1. The installed ARSR-2, En Route Mode S, AN/UPX-27 Beacon System, and CD-2.
- 2. Mode S Analysis Recording Display Equipment (MARDE).
- 3. Real-Time Analysis Display System (RTADS).
- 4. Radar and Beacon Performance Analysis programs.
- 5. Miscellaneous test equipment, e.g., oscilloscope, digital multimeter (DMM), +12 volt (V) direct current (DC) power supply, etc.

b. Trinidad En Route Radar Facility (TAD).

1. The installed ARSR-2, ATCBI-3, and CD-2.
2. Northwest Mountain Region's Radio Frequency (RF) Interference Monitor (RFIM) van ("Born-Free", license number DOT32723).
3. Albuquerque (ZAB) ARTCC HOST computer systems and the QARS, RARRE, BFTA, and COMDIG programs.
4. Denver (ZDV) ARTCC HOST computer system and QARS program.
5. Miscellaneous test equipment, e.g., oscilloscope, DMM, +12V DC power supply, etc.

All of the test equipment used was in calibration. The Trinidad En Route Radar Facility (TAD) was not decertified during the FGAR installation. The Albuquerque (ZAB) and Denver (ZDV) ARTCCs were certified operational facilities.

5. ELECTROMAGNETIC PERFORMANCE TESTS.

Electromagnetic performance testing was divided between the Technical Center's Elwood ERBTF and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD).

The electromagnetic performance testing was conducted under good, dry weather conditions, with the exception of 1 day's testing at the Technical Center's Elwood ERBTF which was performed after 2 days of rain.

5.1 ELWOOD ERBTF.

5.1.1 Mode S Electromagnetic Performance Tests.

a. Objective.

The objective was to collect Mode S data, using the Calibration Performance Monitoring Equipment (CPME) and the output of the CD-2, with the inflatable radome, without a radome, and with the FGAR installed. To analyze the data and compare it to determine if the FGAR degraded the performance of the Mode S.

b. Criteria.

The difference(s) measured between the Mode S electromagnetic performance parameters with the inflatable radome, without a radome, and with the FGAR installed, if any, do not exceed the following:

1. Main beam width change of $\pm 0.05^\circ$ maximum.
2. Boresight error 0.0085° root-mean-square (RMS) and 0.0255° maximum, in either the elevation (vertical) or azimuth (horizontal) plane.
3. Sidelobe level error of ± 1 decibel (dB), using a sidelobe that is -25 dB below the main lobe of reference, for all frontal and back lobes.

4. Azimuth pointing accuracy of the Mode S antenna is not degraded.

c. Description.

Mode S electromagnetic performance data were collected, analyzed, and compared using the programs available at the Technical Center (see appendix B), to evaluate the following:

1. Beacon false targets.
2. Distribution of monopulse values.
3. Range and azimuth accuracy of fixed targets.
4. Beacon and search performance parameters.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the Mode S antenna pattern?

5.1.2 Data Collection and Analysis Method.

Data were recorded with the inflatable radome installed, without a radome, and again after the FGAR was installed. The data were normally collected in the morning, between 0700 and 0900 hours local time. The collection periods consisted of a minimum of 200 scans.

The data were collected by three different methods:

a. Mode S/MARDE.

Mode S data were collected via the MARDE. This data consisted of all interrogations, target replies and reports, surveillance track file data, and dissemination data.

b. Mode S/RTADS.

Mode S dissemination data were collected by the RTADS, in CD-2 format, at the Mode S modem port.

c. CD-2/RTADS.

The CD-2 output data were collected by the RTADS, using the ARSR-2 and either the Mode S in Interim Beacon Initiative (IBI) mode or the AN/UPX-27 Beacon System.

Upon completion of testing, ACW-100 engineers analyzed the data recorded, using the analysis programs available at the Technical Center (see appendix B). They compared the inflatable radome data, to no radome installed data, to the FGAR installed data.

5.1.3 Results and Discussion.

The effect of the FGAR on the electromagnetic performance of the Mode S and AN/UPX-27 Beacon System installed at the Elwood ERBTf was evaluated. The Mode S was tested in the beacon-only configuration since the Mode S to CD-2 interface was not available.

The data recorded without a radome installed showed greater errors than with either the inflatable or the FGAR installed. The increase in the amount of the errors can only be attributed to wind loading on the radar antennas. A

similar situation occurred during testing at the Trinidad En Route Radar Facility (TAD).

The results of the individual analysis programs are discussed in the following paragraphs.

5.1.3.1 Beacon False Target Summary.

After the FGAR was installed, the false beacon target percentages showed an average decrease of 0.15 percent. There is no established national standard for the percentage of false beacon targets. See table 5.1.3.1-1.

The percentages for split targets, ring-around, uplink and downlink reflections, and pulse repetition frequency (PRF), are within the nominal tolerances defined in FAA Order 6365.3. There is no established national standard for "Other" errors. See tables 5.1.3.1-2 through 5.1.3.1-7.

| | Total False Targets | Total Target Reports | False Target % |
|------------|---------------------------|----------------------------|----------------------|
| Inflatable | 318.4 | 60077.7 | 0.51 |
| FGAR | 211.2 | 60390.0 | 0.36 |

TABLE 5.1.3.1-1 AVERAGE BEACON FALSE TARGETS

| Nominal <0.2% | Total | % |
|---------------|-------|------|
| Inflatable | 19.1 | 0.03 |
| FGAR | 8.7 | 0.01 |

TABLE 5.1.3.1-2 AVERAGE SPLIT TARGETS

| Nominal <1.0% | Total | % |
|---------------|-------|------|
| Inflatable | 0.0 | 0.00 |
| FGAR | 0.3 | 0.00 |

TABLE 5.1.3.1-3 AVERAGE RING-AROUND

| Nominal <1.0% | Total | % |
|---------------|-------|------|
| Inflatable | 0.3 | 0.00 |
| FGAR | 0.8 | 0.00 |

TABLE 5.1.3.1-4 AVERAGE DOWNLINK REFLECTIONS

| Nominal <1.0% | Total | % |
|---------------|-------|------|
| Inflatable | 1.0 | 0.00 |
| FGAR | 5.3 | 0.08 |

TABLE 5.1.3.1-5 AVERAGE PRF

| Nominal <1.0% | Total | % |
|---------------|-------|------|
| Inflatable | 1.1 | 0.00 |
| FGAR | 1.3 | 0.08 |

TABLE 5.1.3.1-6 AVERAGE UPLINK REFLECTIONS

| | Total | % |
|------------|-------|------|
| Inflatable | 170.3 | 0.16 |
| FGAR | 115.8 | 0.19 |

TABLE 5.1.3.1-7 AVERAGE OTHER ERRORS

5.1.3.2 Monopulse Analysis.

The monopulse accuracy was measured using the Mode S CPMEs, whose location is accurately known. After installation of the FGAR, there was no degradation of the Mode S azimuth accuracy across the antenna beam. The Mode S azimuth accuracy remained within the 0.068° RMS required by specification FAA-E-2716.

5.1.3.3 Nine Point Analysis.

A summary of the Nine Point Analysis, totals were used as an overall means of evaluating the tracking data. Data were collected from the: (1) Mode S, (2) CD-2 with the Mode S operating in the IBI mode, and (3) CD-2 with the AN/UPX-27 Beacon System.

To provide the greatest accuracy the targets were filtered using the Radar Beacon Analysis Tool (RBAT) program. The targets selected had a range of 5 to 200 nautical miles (NM), an azimuth of 0° to 360°, an altitude of 5,000 to 50,000 feet, and a elevation angle of 0.5° to 35°. The targets were both Mode S and Air Traffic Control Radar Beacon System (ATCRBS), with a radial or tangential flight path, had a high detection code reliability and confidence, and were not climbing/descending or performing any other maneuvers. Specification FAA-E-2716 specifies a maximum allowable azimuth error of 0.068° RMS.

a. Range.

The range error improved very slightly after the FGAR was installed. There was a 0.3 percent improvement with the Mode S, and a 1.1 percent improvement with the CD-2

operating with either the Mode S in IBI mode or the AN/UPX-27 Beacon System. The average range errors are shown in table 5.1.3.3-1.

| | Range Error (NM) | | |
|------------|---------------------|------------|-----------|
| | Mode S | Mode S IBI | AN/UPX-27 |
| Inflatable | 0.0439 | 0.0448 | 0.0446 |
| FGAR | 0.0438 | 0.0438 | 0.0441 |

TABLE 5.1.3.3-1 AVERAGE RANGE ERRORS

b. Azimuth.

The azimuth error was degraded slightly after the FGAR was installed. There was a 7.8 percent degradation of the Mode S and the CD-2 operating with the Mode S in IBI mode, and a 9.1 percent degradation with the CD-2 operating with the AN/UPX-27 Beacon System. The errors do not exceed the 0.068° RMS maximum specified by specification FAA-E-2716. See table 5.1.3.3-2.

| | Azimuth Error (°) | | |
|------------|----------------------|------------|-----------|
| | Mode S | Mode S IBI | AN/UPX-27 |
| Inflatable | 0.0524 | 0.1589 | 0.1421 |
| FGAR | 0.0565 | 0.1465 | 0.1551 |

TABLE 5.1.3.3-2 AVERAGE AZIMUTH ERRORS

5.1.3.4 Surveillance Analysis.

The average total probability of detection (PD) and altitude reliability and confidence levels were improved for the Mode S and ATCRBS after the FGAR was installed. The PD improved by 0.06 percent, the altitude reliability by 0.31 percent, and the altitude confidence by 0.44 percent. The identification (ID) reliability and confidence levels, however, were degraded by 0.14 percent and 0.10 percent, respectively.

The majority of the parameters were improved by the FGAR installation. The amount the two parameters were degraded is insignificant.

5.1.3.5 Fruit Analysis.

The average Mode S and ATCRBS fruit levels measured after the FGAR was installed were lower. There was approximately a 22 percent decrease in the Mode S and a 5 percent decrease in the ATCRBS fruit level. The changes in fruit levels were attributed to the random nature of fruit and the limited number of data samples. The average fruit levels are shown in table 5.1.3.5-1.

| | Fruit Level | |
|------------|-------------|--------|
| | Mode S | ATCRBS |
| Inflatable | 515.1 | 884.8 |
| FGAR | 401.3 | 840.8 |

TABLE 5.1.3.5-1 AVERAGE FRUIT LEVEL

5.2 TRINIDAD EN ROUTE RADAR FACILITY (TAD).

The Trinidad En Route Radar Facility (TAD) electromagnetic performance testing was divided between testing performed at the site and the Albuquerque (ZAB) and Denver (ZDV) ARTCCs.

5.2.1 Trinidad En Route Radar Facility (TAD) Site Tests.

5.2.1.1 Primary (ARSR) and Secondary (ATCRBS) Radar Electromagnetic Performance Tests.

a. Objective.

The objective was to collect primary (ARSR) and secondary (ATCRBS) radar electromagnetic performance data to determine if the: (1) main beam width, (2) boresight error, (3) sidelobe level error, changed, if any.

b. Criteria.

The difference(s) measured between the primary (ARSR) and secondary (ATCRBS) radars electromagnetic performance parameters, without a radome installed and with the FGAR installed, if any, do not exceed the following:

1. Maximum main beam width change of $\pm 0.05^\circ$.
2. Boresight error of 0.0085° RMS and 0.0255° maximum, in either the elevation or azimuth plane.
3. Sidelobe level error change of ± 1 dB, using a sidelobe that is -25 dB below the main lobe of reference, for all frontal and back side lobes.

c. Description.

The testing measured electromagnetic parameters included in specification FAA-E-2773b which were not tested during Design Qualification Testing (DQT).

Primary (ARSR) and secondary (ATCRBS) electromagnetic performance data were collected, analyzed, and compared using the RFIM van and its programs.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) antenna patterns?

5.2.1.2 Data Collection and Analysis Method.

The primary (ARSR) and secondary (ATCRBS) radars azimuth (horizontal) electromagnetic performance parameters were measured by ANM-464 engineers, using their RFIM van. The measurements were made from three locations approximately 120° apart, around the antenna tower (see appendix C). The use of a Global Positioning System (GPS) receiver allowed them to locate the van in exactly the same location each time.

The primary (ARSR) and secondary (ATCRBS) radars elevation (vertical) measurements were made by tracking the sun at sunrise and again at sunset as described in Chapter 17, Radar Antenna Pattern Measurement by Solar Means, FAA Order 6050.32.

The data were collected and analyzed by programs available in the RFIM van. The ANM-464 engineers compared the original radome data, to no radome data, to the FGAR installed data.

5.2.1.3 Results and Discussion.

Solar measurements were used to measure the elevation (vertical) plane electromagnetic performance parameters, using the sun as a source of RF energy. A comparison of the data recorded with no radome installed to that with the FGAR installed, showed no measurable difference.

The horizontal plane data collected without a radome installed were erratic due to wind loading. The results of the horizontal plane electromagnetic performance parameter measurements were:

a. Antenna Main Lobe Beam Width Change.

The average measured 3 dB beam width of the original radome was 1.58°, the FGARs average measured beam width was 1.55°. The change in the antenna main lobe beam width was 0.03°, which is within the specified tolerance.

b. Boresight Error.

The measured boresight error with the original radome and the FGAR were identical.

c. Sidelobe Level Error Change.

The difference between no radome and with the FGAR installed was 0.78 dB, which is within the specified tolerance.

5.2.2 ARTCC QARS Program Tests.

The ARTCCs collect data from all radar facilities supplying data to their facilities and analyze it using their HOST computer system and the QARS program (see appendix B). The QARS program output data are used to determine if the data from the radar facilities is usable for air traffic control (ATC).

The Trinidad En Route Radar Facility (TAD) supplies data to both the Albuquerque (ZAB) and Denver (ZDV) ARTCCs. The Albuquerque (ZAB) and Denver (ZDV) ARTCCs supported the OT&E Operational testing by analyzing the QARS output data for a period of time prior to the removal of the original radome to the data received after the FGAR was installed. The Technical Support Staff (TSS)/Technical Support Office (TSO) engineers at the respective ARTCCs forwarded the output data to the Technical Center for analysis.

a. Objective.

The objective was to determine if there were any difference(s) in the performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar data received by the ARTCCs after the FGAR was installed.

b. Criteria.

The primary (ARSR) and secondary (ATCRBS) radar performance characteristics measured at the ARTCC by the QARS program are not degraded by the FGAR.

c. Description.

The Albuquerque (ZAB) and Denver (ZDV) ARTCCs ran the QARS program on their HOST computer system using primary (ARSR) and secondary (ATCRBS) data from the Trinidad En Route Radar Facility (TAD).

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars?

d. Data Collection and Analysis Method.

A representative sampling of QARS data have been tabulated. In addition, the secondary radar (ATCRBS) PD (same as Blip/Scan ratio), the Mode 3/A validity (Mode 3/A Val.), and Mode C validity (Mode C Val.) have been graphed. These data are presented in appendix D.

e. Results and Conclusions.

The parameters measured by the QARS program were within established national standards as defined in FAA Order 6100.1C.

5.2.2.1 Denver ARTCC (ZDV) QARS Program Test.

a. Data Collection and Analysis Method.

The Denver ARTCC (ZDV) TSO Staff Engineers analyzed the QARS data for the period of October 9 through November 15, 1994, excluding the 10 days when the radars were shutdown for installation of the FGAR.

Their analysis was directed towards the critical parameters, e.g., blip scan ratio, search reinforcement, azimuth splits, range splits, Mode 3/A and Mode C validity and reliability, etc. They also queried the personnel operating the Systems Maintenance Monitor Console (SMMC) and the ATCSs.

Upon completion of running the QARS program on the original radome data and with the FGAR installed, the TSO engineers compared the data to determine if there were any change(s) in the accuracy of the data or any other anomalies.

b. Results and Conclusions.

The TSO staff engineers concluded the installation of the FGAR did not have any noticeable effect on the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars.

5.2.3 Albuquerque ARTCC (ZAB) Tests.

a. Objective.

The objective was to determine if there were any difference(s) in the measured performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar data being received by the ARTCC after the FGAR was installed.

b. Criteria.

The performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar reinforced radar, beacon false targets, and CD-2 data being received by the ARTCC are not degraded by the FGAR.

c. Description.

The Albuquerque ARTCC (ZAB) ran the (1) RARRE, (2) BFTA, and (3) COMDIG analysis programs on their HOST computer system (see appendix B). Data from the Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) radars, were used.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars?

d. Data Collection and Analysis Method.

The data analyzed by the RARRE, BFTA, and COMDIG programs was collected for a period of several hours each time, while the primary (ARSR-2) and secondary (ATCBI-3) radars were operating on the same channels.

Upon completion of running the RARRE, BFTA, and COMDIG programs on the original radome data and with the FGAR installed, the TSS engineers compared the data to determine if there were any change(s) in the data or other anomalies.

e. Results and Discussion.

The results of the RARRE, BFTA, and COMDIG programs were:

1. RARRE.

The overall results of the radar reinforcement analysis were somewhat varied, some parameters were better while others were worse.

- (a) The overall radar reinforcement was 64 percent with the original radome and 62 percent with the FGAR.
- (b) Radar reinforcement in the 50 to 105 NM range was 70 percent with the original radome and 60 percent with the FGAR installed.
- (c) On either side of the 50 to 105 NM range band, the percentages were higher with the FGAR installed.
- (d) Altitude and range plots showed the radar coverage was 1,000 to 2,000 feet worse with the FGAR installed.

- (e) The radar range coverage was reduced from 187 NM with the original radome installed to 185 NM with the FGAR installed.

The overall radar reinforcement percentage reduction may have been caused by small differences in the aircraft traffic patterns at the time the data were recorded.

2. BFTA.

There was a reduction of 0.001 percent in beacon false targets after the FGAR was installed, which is statistically insignificant. The different types of beacon target splits were approximately the same with the original radome when compared to the FGAR, except there were fewer ring-around targets after the FGAR was installed.

3. COMDIG.

En route radar facilities have at least one fixed beacon transponder, referred to as a "parrot", located several miles from the facility. The location of these "parrots" is precisely known and they are used to evaluate the en route radar ATCRBS.

With the original radome installed, nine percent of the "parrot" replies fell outside the two azimuth change pulse (ACP) limit. After the FGAR was installed, only one "parrot" reply out of 1,500 replies (0.067 percent) was outside the two ACP limit.

The TSS engineers who evaluated the data concluded the changes were so slight that they would have no effect on ATC, especially since some of the changes were an improvement.

5.2.4 ARTCC ATCS Evaluation Tests.

Questionnaires were forwarded to the Albuquerque (ZAB) and Denver (ZDV) ARTCCs requesting that journeyman ATCSs, who normally operate displays using Trinidad En Route Radar Facility (TAD) video data, complete them. The questionnaires were divided into three sections: (1) primary radar evaluation, (2) secondary (beacon) radar evaluation, and (3) overall evaluation. The purpose was to determine if the user, the ATCSs, could see any change(s) between the video data displayed with FGAR installed as compared to the original radome.

a. Objective.

The objective was to determine if there were any difference(s) in the primary (ARSR) and secondary (ATCRBS) video data presented to the ATCSs, e.g., apparent strength of targets, loss of targets, or other anomalies, with the FGAR installed as compared to the original radome.

b. Criteria.

The primary (ARSR) and secondary (ATCRBS) video data strength appeared the same to the ATCSs. The number of lost/coasting targets did not increase. There were no other apparent anomalies.

c. Description.

The Albuquerque ARTCC (ZAB) ATCSs who normally operate displays using Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) video data completed a questionnaire.

The critical issue is: Does the FGAR degrade the primary (ARSR) or secondary (ATCRBS) radar video data?

5.2.4.1 Albuquerque ARTCC (ZAB) ATCS Evaluation Test.

a. Data Collection and Analysis Method.

After the questionnaires were completed, they were forwarded by the ARTCC Air Traffic (AT) Plans and Program Section to the Test Director (TD).

b. Results and Discussion.

A total of 30 questionnaires were returned. The responses are tabulated in appendix E. The percentages shown are based on the number of respondents to each question.

1. Part I - Primary Radar Evaluation.

The majority of the ATCSs responses indicated the primary (ARSR) radar was unaffected by the installation of the FGAR.

2. Part II - Secondary (Beacon) Radar Evaluation.

The majority of the ATCSs responses indicated the secondary (ATCRBS) radar was unaffected by the installation of the FGAR. However, six (20.7 percent) of the respondents referred to "speed fluctuations" or "speed changes" in their written comments.

3. Part III - Overall Evaluation.

The majority of the ATCSs responses indicated the overall performance was unaffected by the installation of the FGAR. However, three (11.3 percent) of the respondents referred to "speed fluctuation" or "speed changes" in their written comments.

5.2.4.2 Denver ARTCC (ZDV) ATCS Evaluation Test.

a. Data Collection and Analysis Method.

The ARTCC Manager had the video data evaluated and submitted a report describing the results of the evaluation. The questionnaires were not returned.

b. Results and Discussion.

The ARTCC Airspace and Procedures specialists held discussion sessions with the ATCSs in lieu of completing the questionnaires. The results of these discussions were:

1. The video data appears the same to the ATCSs.

2. There has been no reported increase in the incidence of ring-around, false targets, or beacon code swapping, or other anomalies.

5.2.5 Flight Check.

The Northwest Mountain Region's Establishment Engineering Branch, ANM-450, scheduled a flight check to be performed after the FGAR was installed and the facility was operational. The flight check was performed in two phases:

- a. Inbound.

The inbound phase was flown at an altitude of 15,000 feet mean-sea-level (MSL) in a northeasterly direction (57.1° true North) towards the site. The aircraft was first detected at a range of 133.1 NM and tracked until reaching the cone of silence (an area over the site where the target is lost) at 2.04 NM.

- b. Orbital Coverage.

The orbital coverage phase was flown at an altitude of 8,000 feet MSL, at a range of 10 NM, from an azimuth of 327° to 322°. Primary radar racking was lost when the radar receiver moving target indicator (MTI) filters detected no radial velocity. The ATCBI-3 tracked the aircraft during the complete orbit.

- c. Data Collection and Analysis Method.

Three methods were used to collect data during the flight check: (1) QARS data was recorded at the Denver ARTCC (ZDV), (2) manual scoring at the Denver ARTCC (ZDV) was used to record the whether the primary (ARSR) and secondary (ATCRBS) video data was present on the ATCS displays, and (3) raw CD-2 output data displayed at the Trinidad En Route Radar Facility (TAD) was manually recorded by site personnel.

The QARS data was analyzed using the Common Digitizer Record (CDRECORD) program and the PLOTCD program was used to plot the data.

The manual scoring at the Denver ARTCC (ZDV) was performed by observing whether the primary or secondary radar target video data was presented on an operational Plan View Display (PVD) display.

- d. Results and Discussion.

The following is based on an analysis of the CD-2 and manually scored data recorded at the Denver ARTCC (ZDV).

1. There was no unexpected jitter, drop-outs, or holes (areas where a target is lost) observed that were considered significant during the inbound phase.
2. There was no significant change in the number of beacon false or ring-around targets observed, that might indicate unusual or irregular attenuation, or signal scattering from the radome joints.
3. The FGAR exhibits a negligible effect on the effectiveness of the primary (ARSR) or secondary (ATCRBS) radars.

6. HUMAN ENGINEERING TESTS.

The human engineering tests were divided into two parts: (1) clothing constraints, and (2) electrical. These tests were performed at the Elwood ERBTF.

6.1 CLOTHING CONSTRAINTS TESTS.

a. Objective.

To verify the configuration of the radome access hatches does not present a constraint to personnel, wearing heavy winter clothing, when passing through the hatches. The access hatches latches could be operated by an individual wearing heavy winter gloves.

b. Criteria.

1. Zenith Hatch Assembly mounted equipment can be serviced, repaired, removed, and/or replaced by individuals wearing heavy winter clothing, e.g., parka, insulated suit, heavy winter gloves, etc.
2. An individual can pass through the Catwalk Access Hatch in either direction, with ease, while wearing heavy winter clothing, e.g., parka, insulated suit, heavy winter gloves, etc.
3. Latches used to open the Zenith Service and Catwalk Access Hatches are designed to allow an individual wearing heavy winter gloves to operate them. The latches can be latched/unlatched from either the inside or outside of the radome.

c. Description.

1. The Zenith Hatch Assembly was inspected to verify there is sufficient clearance available for an individual wearing heavy winter clothing, e.g., parka, insulated suit, etc., to service, repair, and/or remove equipment mounted on the Zenith Crown Plate. In addition, the hatch latch handle could be operated while wearing heavy winter gloves.
2. The Catwalk Access Hatch was inspected to verify there is sufficient clearance available for an individual wearing heavy winter clothing, e.g., parka, insulated suit, etc., to pass through in either direction. In addition, the hatch latch could be operated from either side while wearing heavy winter gloves.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-3, HECT-1/2/3 Clothing Constraints Test Data Sheet form. The TD analyzed the data to verify the Zenith Service and Catwalk Access Hatches allowed an individual wearing heavy winter clothing to pass through. In addition, that the hatch latches could be operated by an individual wearing heavy winter gloves.

e. Results and Discussion.

There were no problems found during the tests. The hatches were sufficiently large for an individual, wearing heavy winter clothing, to pass through in either direction. An individual wearing heavy winter gloves could operate the hatch latches.

6.2 ELECTRICAL TESTS.

a. Objective.

To verify the electrical equipment is designed and provided with safety features to prevent personnel injury.

b. Criteria.

1. The circuit breaker (CB), terminal boards (TB), etc., with 30V alternating current (AC) RMS or DC, or greater present during normal operation have covers, shrink tubing, etc., to protect personnel from accidentally contacting current carrying parts.
2. Caution labels are affixed to doors or other means of access to equipment with 30V AC RMS or DC, or greater present during normal operation.
3. The CB is provided with a means of locking it in the open (de-energized) position.

c. Description.

1. The CB, TBs, etc., with 30V AC RMS or DC, or greater present during normal operation, were inspected to verify they have covers, shrink tubing, etc., to protect personnel from accidentally contacting current carrying surfaces.
2. Electrical cabinets, boxes, etc., with 30V AC RMS or DC, or greater present during normal operation, were inspected to verify CAUTION labels were affixed to doors or other means of access.
3. The CB was inspected to verify it was provided with a means of locking it in the open (de-energized) position.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-4, HEET-1/2/3 Electrical Test Data Sheet form. The TD analyzed the data to verify current carrying terminals, etc., are covered to protect against accidental contact, the CB can be locked in an open (de-energized) position, a 120V CAUTION label was present on the RMMS Control Panel door, and there were no other electrical hazards.

e. Results and Discussion.

There were no problems found during the tests. The design of the RMMS Control Panel provides protection against personnel accidentally contacting current carrying parts and provides a means of locking the CB in the open (de-energized) position. Electrical connections in the radome are enclosed in weather tight electrical

boxes. A "120V" caution label is located on the RMMS Control Panel door.

7. PHYSICAL CHARACTERISTICS TESTS.

The Nameplate and Labeling Tests were the only physical characteristics tests performed. These tests were performed at the Elwood ERBTF.

a. Objective.

To verify assemblies and components, e.g., aircraft obstruction light (AOL) assembly, cables, CB, TBs, etc., were correctly, permanently, and legibly labeled.

b. Criteria.

1. Assemblies, e.g., AOL assembly, etc., had a nameplate with the equipment title, designation, and serial number (if applicable) displayed. The nameplate information was:
 - (a) Recorded in a permanent and legible manner, which would not be affected by weather, etc.
 - (b) Permanently affixed to the assembly.
 - (c) Visible, without having to disassemble or remove any parts, covers, etc.
2. The cables, CB, TBs, etc., were correctly, permanently, and legibly labeled with their appropriate designation, value, or other descriptive information, e.g., ON/OFF for CB position, etc., as appropriate.

c. Description.

1. Assemblies, e.g., AOL, etc., were inspected to verify they had a nameplate with the equipment title, designation, and serial number (if applicable) displayed. The nameplate information:
 - (a) Was recorded in a permanent, legible manner, which is unaffected by weather, etc.
 - (b) Was permanently affixed to the assembly.
 - (c) Was visible without having to disassemble and/or remove any parts, covers, etc.
2. The cables, CB, TBs, etc., were inspected to verify they were permanently and legibly labeled with their appropriate designation, value, and/or other descriptive information.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-1, PCNP-1/2 Nameplate/Labeling Test Data Sheet form. The TD analyzed the data to determine if all required nameplates, labels, etc., were present.

e. Results and Discussion.

Two problems were found during the testing.

1. The RMMS Control Panel did not have an FA-type number nameplate attached to the outside of the door.
2. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches were not labeled with their designation.

FGAR-9, Test Discrepancy Report (TDR) forms were prepared.

8. PHYSICAL PERFORMANCE TESTS.

The Transient Protection Tests were the only physical performance tests performed. These tests were performed at both the Elwood ERBTf and the Trinidad En Route Radar Facility (TAD).

a. Objectives.

1. To verify the facility electrical and signal systems are protected from induced electrical transients entering through the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable, AOL power cable, or the RMMS Control Panel AOL Adjustable Linear Current Sensor.
2. To verify the RMMS Control Panel AOL Adjustable Linear Current Sensor is not falsely triggered by induced electrical transients.

b. Criteria.

1. There are no induced electrical transients present on the Zenith Service/Catwalk Access Hatch RMMS open/closed monitor cable when measured at the output (facility side) of the RMMS Control Panel.
2. There are no induced electrical transients on the AOL power cable when measured at the input (facility side) of the RMMS Control Panel.
3. There are no induced electrical transients in the output of the AOL Adjustable Linear Current Sensor when measured at the output (facility side) of the RMMS Control Panel.
4. The RMMS Control Panel AOL Adjustable Linear Current Sensor is not falsely triggered by induced electrical transients.

c. Description.

1. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable was monitored for induced electrical transients at the output (facility side) of the RMMS Control Panel, with an oscilloscope.
2. The AOL power cable was monitored for induced electrical transients, at the input (facility side) of the RMMS Control Panel, with an oscilloscope.

3. The output of the AOL Adjustable Linear Current Sensor was monitored for induced electrical transients, at the output (facility side) of the RMMS Control Panel, with an oscilloscope.
4. The output of the AOL Adjustable Linear Current Sensor was monitored at the RMMS Control Panel, with a DMM, to verify it was not being falsely triggered by induced electrical transients.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on FGAR-5, PPTP-1/2/3/4 Transient Protection Test Data Sheet forms. The TD analyzed the data to determine if:

1. There were any transients present on the Zenith Service/Catwalk Access Hatch RMMS open/closed monitor cable, the AOL power cable, or the output of the RMMS Control Panel AOL Adjustable Linear Current Sensor.
2. The AOL Adjustable Linear Current Sensor was not falsely triggered by electrical transients.

e. Results and Discussion.

Problems were found at both the Elwood ERBTF and the Trinidad En Route Radar Facility (TAD). The problems were similar, but of different magnitudes.

1. Elwood ERBTF.

- (a) A 40 V peak-to-peak (P-P) [28.3 V RMS], 60 Hertz (Hz), level was found on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side), with AOL power applied. When AOL power was turned off, the level dropped to 4.3 V P-P (3.0 V RMS).

The AOL power cable and the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable are run in the same conduit between the radar equipment building and the antenna tower platform. The conduit is terminated in a common junction box on the antenna tower platform.

The cables share the same square duct, within the radar equipment building, with many other facility electrical and signal cables. Within the radome, the cables are secured together with cable ties, from the antenna tower platform to the zenith.

- (b) There were no RF transients found on either cable. The Mode S was operating at full power, however, the ARSR-2 was operating with the magnetron only. The amplatron could not be operated due to equipment problems.

2. Trinidad En Route Radar Facility (TAD).

- (a) A 17 V P-P (12.0 V RMS), 60 Hz, level was found on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side), with AOL power applied. When AOL power was turned off, the level dropped to 650 millivolts (mV) P-P (460 mV RMS).

The AOL power cable and the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable are run in separate conduits between the radar equipment building and the antenna tower platform. The conduits are terminated in separate junction boxes on the antenna tower platform.

The cables share the same square duct, within the radar equipment building, with many other facility electrical and signal cables. Within the radome, the cables are secured together with cable ties, from the antenna tower platform to the zenith.

- (b) There were 100 mV peak RF transients present on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side).
- (c) There were 200 mV peak RF transients present at the output of the RMMS Control Panel AOL Adjustable Linear Current Sensor.

The transients were apparently fed down the AOL power cable and passed through the AOL Adjustable Linear Current Sensor circuitry and transient suppressor.

The ATCBI-3 was operating at full power and the ARSR-2 was operating at full power, with the amplatron.

The 60 Hz levels, induced into the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable, will vary from site to site due to the routing of the cable though the same square duct and cable troughs in the radar equipment building, etc. The RF transient levels should remain relatively constant since the amount of cable exposed to RF energy should be approximately the same.

The same level of induced 60 Hz and RF transients were found on both sides of the RMMS Control Panel transient protectors. The ERMS will interface directly with the output of these transient protectors.

FGAR-9, Test Discrepancy Report (TDR) forms were prepared.

9. CONCLUSIONS.

9.1 DQT TESTING.

The Functional Configuration Audit (FCA) uncovered one test issue still open. Paragraph 3.2.1, FAA-E-2773b, requires all electromagnetic performance parameters be met while operating under the environmental conditions listed in

paragraph 3.2.5, FAA-E-2773b. The environmental condition are:

- a. High and low ambient temperatures
- b. Relative humidity
- c. Altitude
- d. Salt atmosphere
- e. Maximum wind speed
- f. Maximum operating snow or ice load
- g. Hail impact

There has been no electromagnetic performance testing under the environment conditions specified in paragraph 3.2.5, FAA-E-2773b. The FGAR DQT electromagnetic performance testing was performed under dry conditions, near sea level, and at room temperature. OT&E Operational testing was performed in dry conditions, near sea level and at approximately 5000 feet altitude, and at temperatures ranging between 60° and 90° Fahrenheit (°F).

9.2 OT&E OPERATIONAL TESTING.

Based upon the results of OT&E Integration and Operational testing, the following conclusions about the Type I/III FGAR can be drawn:

- a. The FGAR does not degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS and Mode S) radars.
- b. The FGAR does not present any safety hazards or problems to personnel who must maintain it.
- c. The RMMS Control Panel needs an FA-type number label installed,
- d. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches need to be labeled.
- e. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL Adjustable Linear Current Sensor RMMS Control Panel transient protectors do not eliminate or reduce the induced 60 Hz levels or RF transients. The 60 Hz levels and/or RF transients could degrade the operation or damage the ERMS, when it is installed.

10. RECOMMENDATIONS.

The results of OT&E Integration and OT&E Operational testing uncovered no major problems with the Type I/III FGAR. The FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA. It is recommended that the FGAR's be integrated into the NAS.

It is recommend that the following minor discrepancies be corrected:

- a. An FA-type number label be affixed to the RMMS Control Panel door.
- b. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches be labeled with their designation.

- c. The RMMS Control Panel Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL Adjustable Linear Current Sensor transient protectors be replaced with a type that will eliminate RF transients and 60 Hz.
- d. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL power cable:
 - 1. Be run in separate conduits between the radar equipment building and the antenna tower platform.
 - 2. Be terminated in separate junction boxes on the antenna tower platform.
 - 3. Be separated as widely as possible, within the radome.
- e. An Engineering Change Proposal (ECP) be generated that addresses the electromagnetic performance parameters not tested while operating under the environmental conditions specified in paragraph 3.2.5, FAA-E-2773b.

11. ACRONYMS AND ABBREVIATIONS.

| | |
|--------|---|
| ° | Degree(s) |
| > | Greater Than |
| < | Less Than |
| # | Number |
| % | Percent(age) |
| AC | Alternating Current |
| ACP | Azimuth Change Pulse(s) |
| AFS | Airway Facilities Sector |
| AN/UPX | Army-Navy/General Utility Radar Identification and Recognition (military designation) |
| AOL | Aircraft Obstruction Light(s) |
| ARSR | Air Route Surveillance Radar |
| ARTCC | Air Route Traffic Control Center |
| AT | Air Traffic |
| ATC | Air Traffic Control |
| ATCBI | Air Traffic Control Beacon Interrogator |
| ATCRBS | Air Traffic Control Radar Beacon System |
| ATCS | Air Traffic Control Specialist |
| AZ | Azimuth (QARS program) |

| | |
|----------|---|
| BCN | Beacon (QARS program) |
| BFTA | Beacon False Target Analysis (a computer program) |
| CB | Circuit Breaker |
| CD | Common Digitizer |
| CDRECORD | Common Digitizer Record (a computer program) |
| CO | Colorado |
| COLL | Collimation (QARS program) |
| COMDIG | Common Digitizer Data Reduction (a computer program) |
| CPME | Calibration Performance Monitoring Equipment |
| dB | Decibel |
| DC | Direct Current |
| DEG | Degree(s) |
| DEV | Deviation (QARS program) |
| DMM | Digital Multimeter |
| DQT | Design Qualification Test(ing) |
| DRG | Data Receiver Group |
| DRR | Deployment Readiness Review |
| ECP | Engineering Change Proposal |
| ERBTF | En Route Beacon Test Facility |
| ERMS | Environmental Remote Monitoring Subsystem |
| ESSCO | Electronic Space Systems Corporation (company name) |
| F | Fahrenheit |
| FAA | Federal Aviation Administration |
| FCA | Functional Configuration Audit |
| FGAR | Fixed Ground Antenna Radome |
| GFE | Government Furnished Equipment |
| GPS | Global Positioning System |
| HOST | Air Traffic Control HOST Computer System (not an acronym) |
| Hz | Hertz |
| IBI | Interim Beacon Initiative |
| IBM | International Business Machines (company name) |

| | |
|---------|--|
| ID | Identification |
| LOG/NML | Logarithmic Normal (QARS program) |
| LPS | Lightning Protection Subsystem |
| MA | Massachusetts |
| MARDE | Mode S Analysis Recording Display Equipment |
| Mode S | Mode Select Beacon System |
| MSL | Mean Sea Level |
| MTI | Moving Target Indicator |
| mV | Millivolt |
| NAS | National Airspace System |
| NJ | New Jersey |
| NM | Nautical Mile |
| NML | Normal (QARS program) |
| NO. | Number |
| OT&E | Operational Test and Evaluation |
| P-P | Peak-to-Peak |
| PC | Personal Computer |
| PD | Probability of Detection |
| PE | Permanent Echo (QARS program) |
| PRF | Pulse Repetition Frequency |
| PVD | Plan View Display |
| QARS | Quick Analysis of Radar Sites (a computer program) |
| RARRE | Range, Azimuth, Radar Reinforcement Evaluator (a computer program) |
| RBAT | Radar Beacon Analysis Tool (a computer program) |
| REFL | Reflection(s) |
| REL | Reliability (QARS program) |
| RF | Radio Frequency |
| RFIM | Radio Frequency Interference Monitoring |
| RMMS | Remote Maintenance Monitoring System |
| RMS | Root-Mean-Square |
| RNG | Range (QARS program) |

| | |
|---------|---|
| RPTS | Reports |
| RTADS | Real-Time Analysis Display System |
| SCH/BCN | Combined Moving Target Indicator and Normal Video/Beacon (QARS program) |
| SEC | Second(s) |
| SMMC | Systems Maintenance Monitor Console |
| TAD | Trinidad En Route Radar Facility (identifier) |
| TB | Terminal Board |
| TD | Test Director |
| TDR | Test Discrepancy Report |
| TGT | Target(s) |
| TGTS | Targets |
| TRACS | Transportable Radar Analysis Computer System |
| TSO | Technical Support Office |
| TSS | Technical Support Staff |
| TX | Texas |
| V | Volt(s) |
| VAL | Validity |
| ZAB | Albuquerque Air Route Traffic Control Center (identifier) |
| ZDV | Denver Air Route Traffic Control Center (identifier) |

APPENDIX A

TEST PARTICIPANTS

TEST PARTICIPANTS

The personnel, and their organization, who participated in the individual tests are listed below:

1. Elwood ERBTF.

a. Mode S Electromagnetic Performance Tests.

Andrew Leone, Electronic Engineer, ACW-100B

George Montgomery, Engineer, MiTech/ACW-100B

b. Human Engineering - Clothing Constraints Tests.

Michael Freie, Electronic Engineer, ANR-800

Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

Leonard Schrock, Senior Field Service Supervisor, Electronic Space Systems Corporation (ESSCO)

Ken Romanwiz, Field Service Technician, ESSCO

c. Human Engineering - Electrical Tests.

Michael Freie, Electronic Engineer, ANR-800

Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

d. Physical Characteristics - Nameplate/Labeling Tests.

Michael Freie, Electronic Engineer, ANR-800

Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

e. Physical Performance - Transient Protection Tests.

Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

2. Trinidad En Route Radar Facility (TAD).

a. Primary Radar Electromagnetic Performance Tests.

Harry J. Gardner, Spectrum Management Officer, ANM-464J

James L. Ulm, Spectrum Management Officer, ANM-464I

b. ATCRBS Electromagnetic Performance Tests.

Harry J. Gardner, Spectrum Management Officer, ANM-464J

James L. Ulm, Spectrum Management Officer, ANM-464I

c. Albuquerque ARTCC (ZAB) QARS Program Tests.

Staff Engineers, TSS, Albuquerque ARTCC (ZAB) AFS

d. Denver ARTCC (ZDV) QARS Program Tests.

Staff Engineers, TSO, Denver ARTCC (ZDV) AFS

- e. Albuquerque ARTCC (ZAB) ATCS Evaluation Test.
ATCSs, Albuquerque ARTCC (ZAB)
- f. Denver ARTCC (ZDV) ATCS Evaluation Test.
ATCSs, Denver ARTCC (ZDV)
- g. Physical Performance - Transient Protection Tests.
Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B
Jeffrey L. Hobbs, Senior Engineer, Vitro/ANR-400

APPENDIX B

DATA ANALYSIS PROGRAMS

DATA ANALYSIS PROGRAMS

1. Technical Center.

The programs used at the Technical Center to analyze the electromagnetic performance of the Elwood ERBTF secondary radar (Mode S) were:

- a. Beacon False Target Summary - Analyzes false beacon targets in azimuth, i.e., target splits, ring around, and uplink and downlink reflections. The uplink reflections are used to calculate the location and orientation of the reflectors. Range versus azimuth, range versus altitude, and azimuth versus altitude plots are provided for the false targets. The program also provides a plot of the reflections.
- b. Monopulse Analysis - Analyzes the distribution of monopulse values for a stationary target. Plots of monopulse versus antenna azimuth, azimuth error versus antenna azimuth, absolute value of azimuth error versus antenna azimuth, mean and standard deviation, the Mode S Sensor monopulse table, and scatter plots of the raw data points are provided.
- c. Nine Point Analysis - Analyzes the range and azimuth accuracy of the target reports for a given target. The reference range and azimuth positions are determined using a nine point curve fit centered on the target report of interest.
- d. Surveillance Analysis - Analyzes beacon and search performance for all beacon tracks. Statistics are provided individually for each track and combined into ATCRBS, Mode S, and total categories. Range versus azimuth, range versus altitude, and azimuth versus altitude plots are provided which contain track initiations, coasts, and drops.
- e. Fruit Analysis - Calculates the ATCRBS and Mode S fruit rates coming into the Mode S Sensor. Statistics are given for each sector and combined into totals for all the sectors. These statistics are provided every minute for the duration of the filter time interval. The fruit rates are tabulated and plotted.
- f. Mode S Extraction Plot - Plots replies and reports from a Mode S extraction file.
- g. Radar Beacon Analysis Tool (RBAT) - Similar to the Nine Point Analysis program, except CD-2 data is used.

2. Northwest Mountain Region RFIM Van Programs.

The commercial software programs used by the Northwest Mountain Region's RFIM van to analyze the electromagnetic performance of the Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) were:

- a. LabWindows, Version 2.1 - National Instruments, Inc., Austin, Texas (TX).
- b. EasyPlot for Windows, Version 2.2 - Spiral Software, Inc., Brookline, Massachusetts (MA).

3. ARTCC Computer Programs.

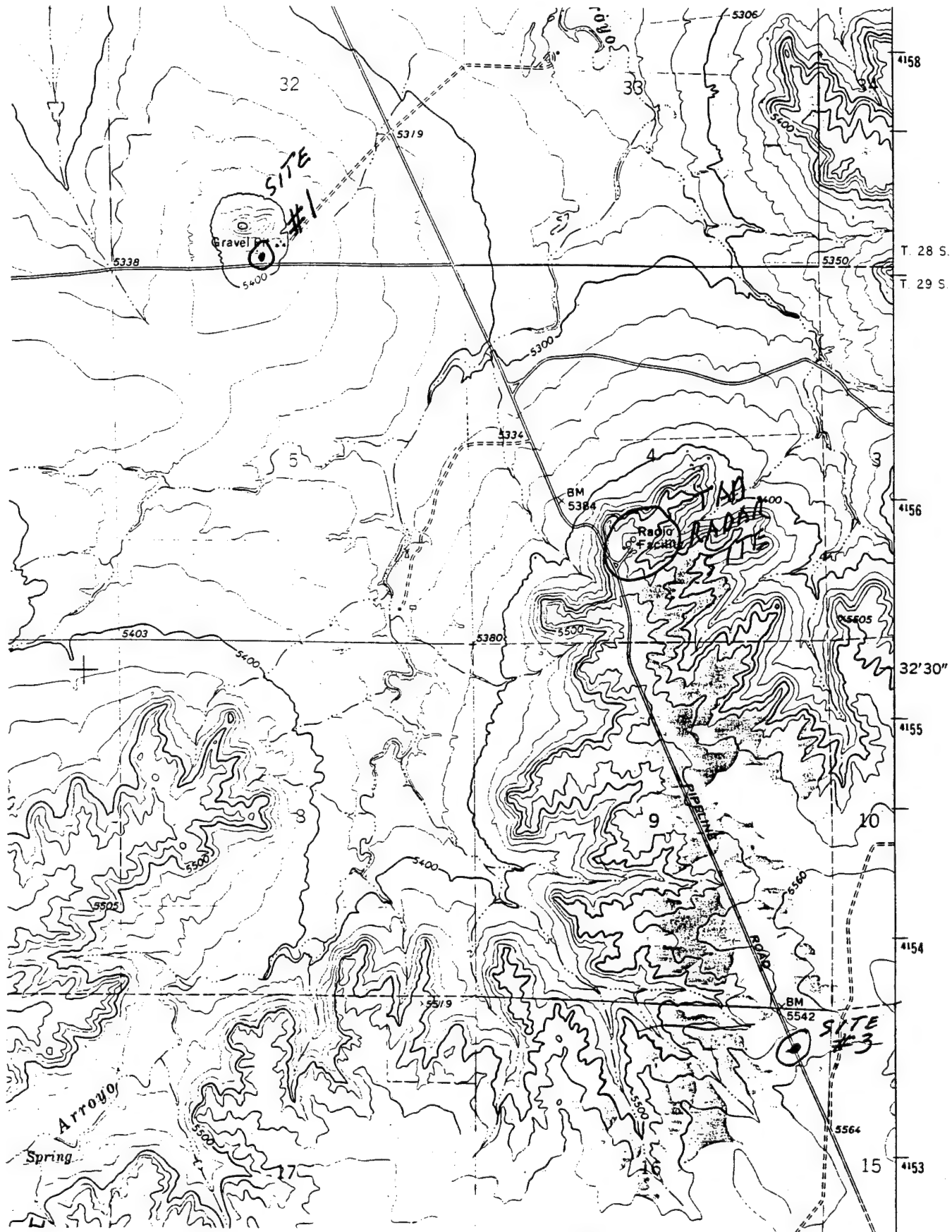
The programs used at the ARTCCs to analyze the electromagnetic performance of Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) data were:

- a. Quick Analysis of Radar Sites (QARS) - The QARS program provides confirmation of an ARTCCs CD interface and operational status. The data can be either real time or a CDRECORD format tape. The QARS program is run on the HOST computer system.
- b. Range, Azimuth, Radar Reinforced Evaluator (RARRE) - The RARRE program provides the capability to retrieve, sort, and print target information pertaining to all Mode 3/A beacon equipped aircraft detected by any number of radar sites. The data are received from a CDRECORD format tape. The RARRE program is run on the HOST computer system.
- c. Beacon False Target Analysis (BFTA) - The BFTA program is a tool to investigate and evaluate the false target problem in the NAS automated ATCRBS radar system. The BFTA program is run on the HOST computer system.
- d. Common Digitizer Data Reduction (COMDIG) - The COMDIG program extracts selected types of data from a CDRECORD program tape containing various mixtures of the six CD message types received by the HOST computer system and prints the data in the prescribed formats. The COMDIG program is run on the HOST computer system.
- e. Common Digitizer Record (CDRECORD) - The CDRECORD program provides the capability to record on magnetic tape, CD data as received over the Data Receiver Group (DRG)/HOST computer system interface. The CDRECORD program is run on the HOST computer system.
- f. PLOTCD - The PLOTCD program provides the capability to plot and sort aircraft and weather data in a polar presentation on a International Business Machines Corporation (IBM) compatible personal computer (PC) graphics display. The target data is retrieved from a CDRECORD disk file. The PLOTCD program is run on the Transportable Radar Analysis Computer System (TRACS) PC.

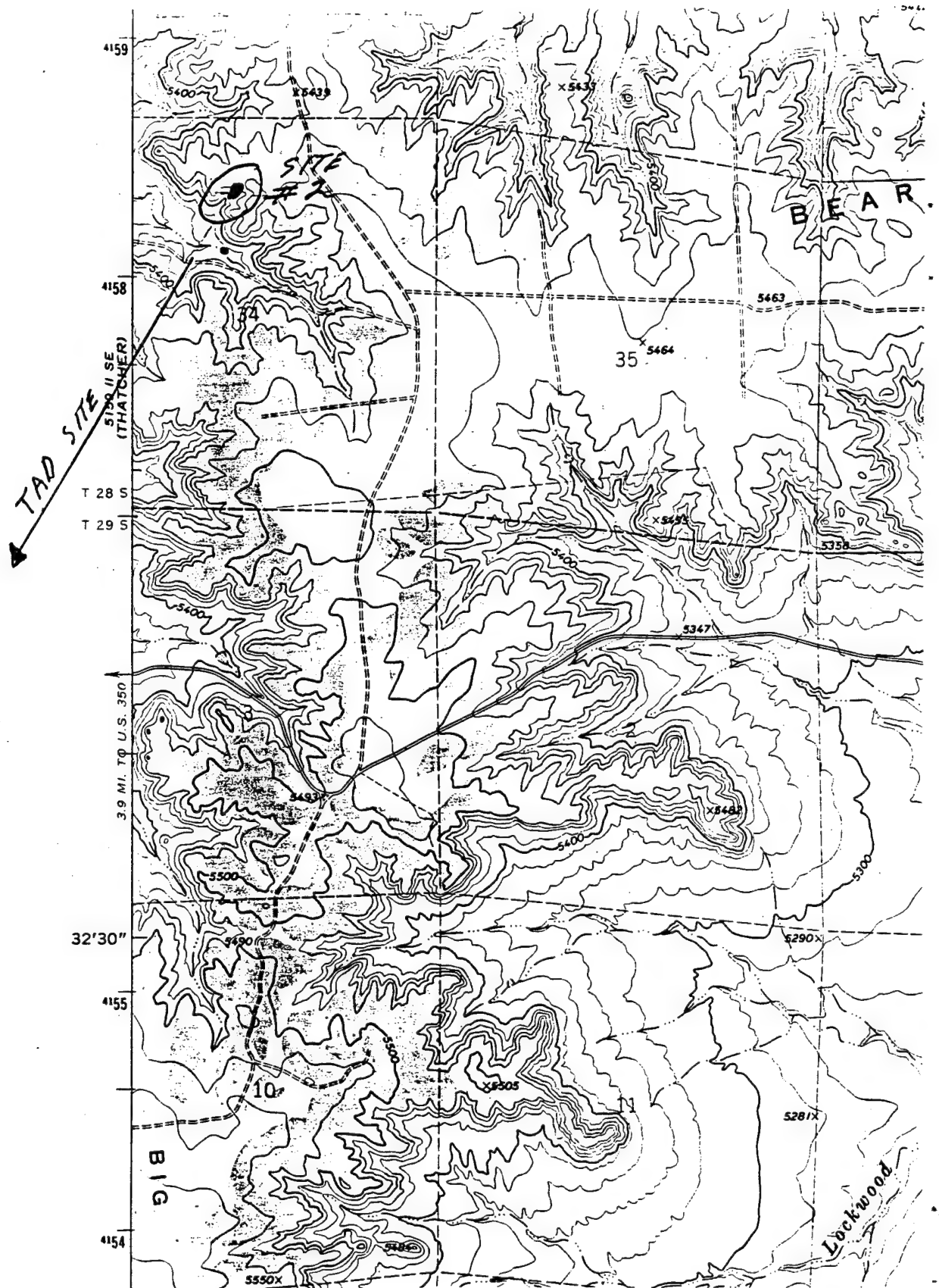
APPENDIX C

RFIM VAN LOCATIONS

TRINIDAD EN ROUTE RADAR FACILITY (TAD)



Thatcher Quadrangle, Las Animas County, Colorado - 1970
 7.5 Minute (Topographic)
 Scale 1:24,000, Contour Interval 20 Feet



Lockwood Arroyo Quadrangle, Las Animas County, Colorado - 1984
 7.5 Minute (Topographic)
 Scale 1:24,000, Contour Interval 20 Feet

APPENDIX D

QARS DATA

ALBUQUERQUE (ZAB) AND DENVER (ZDV) ARTCC

[illegible]

D-1

Denver QARS Data for Trinidad, CO

| Radome Type | Full Criteria | Old 10/3/94 | Old 10/5/94 | Open 10/26/94 | FGAR 11/3/94 | FGAR 11/4/94 | FGAR 11/5/94 | FGAR 11/6/94 | FGAR 11/7/94 | FGAR 11/9/94 | FGAR 11/10/94 |
|-------------------|---------------|----------------|----------------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|
| BEACON | | | | | | | | | | | |
| Scans | | 34815 | 27533 | 19876 | 30935 | 27268 | 27634 | 23990 | 25720 | 25242 | 22074 |
| Blip/Scan | <96% | 99.4 | 99.4 | 98.8 | 99.2 | 99.3 | 98.1 | 98.7 | 99.3 | 99.7 | 98.4 |
| Search/Reinforced | <85/60/50% | 79.9 | 82.4 | 32.2 | 82.0 | 80.5 | 68.9 | 80.3 | 78.6 | 83.0 | 65.7 |
| Total Coll % | <98/85/70% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Az.Split | >1/2/2% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rng.Split | >1/2/5% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ring-Around | >5% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Reflections | >2% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Code 0000s | >5% | 0.1 | 0.3 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| Mode 3/A Rel. | <98% | 99.4 | 98.8 | 99.2 | 98.9 | 98.9 | 99.0 | 98.8 | 99.3 | 99.7 | 98.9 |
| Mode 3/A Val. | <98% | 98.9 | 98.0 | 98.5 | 98.1 | 98.2 | 98.3 | 98.0 | 98.9 | 99.5 | 98.1 |
| Mode C Val. | <98/97% | 99.6 | 99.2 | 99.4 | 99.4 | 99.4 | 99.4 | 99.2 | 99.5 | 99.8 | 99.4 |
| Mode C Rel. | <97/95% | 99.2 | 98.4 | 98.7 | 98.6 | 98.7 | 98.9 | 98.4 | 98.0 | 99.5 | 98.9 |
| Mode C Scans | | 34561 | 27338 | 19579 | 30662 | 27028 | 26971 | 23602 | 25517 | 25161 | 21634 |
| Rng. Dev. | >0/1 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| Az.Dev. | >2.0 | 1.67 | 1.69 | 1.61 | 1.7 | 1.73 | 1.63 | 1.67 | 1.64 | 1.66 | 1.52 |
| LOG/NML | | | | | | | | | | | |
| Scans | | 23393 | 19119 | 13341 | 21407 | 18908 | 18573 | 15981 | 16817 | 18117 | 12932 |
| Blip/Scan | <85/75/75% | 79.0 | 81.8 | 32.9 | 82.8 | 81.5 | 69.5 | 83.8 | 81.2 | 82.7 | 66.5 |
| Coll % | <96/85/70% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Az.Splits | >2% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| Rng.Splits | >3/3/6% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTI | | | | | | | | | | | |
| Scans | | 11422 | 8414 | 6535 | 9528 | 8360 | 9061 | 8009 | 8903 | 7125 | 9142 |
| Blip/Scan | <85/70/65% | 81.2 | 83.4 | 29.8 | 79.2 | 77.2 | 64.7 | 71.6 | 73.1 | 83.2 | 62.9 |
| Coll % | <98/85/70% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Az.Splits | >2% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rng.Splits | >3/3/6% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PE VERIFICATION | | | | | | | | | | | |
| #1 Rng. Error | >0/1 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| #1 Az. Error | >2.0 | 1.0 | 1.0 | 1.3 | 0.4 | 0.2 | 0.4 | 0.5 | 0.3 | 0.3 | 0.6 |
| #1 % Rel. | <90% | 100.0 | 100.0 | 98.0 | 100.0 | 100.0 | 100.0 | 96.0 | 100.0 | 100.0 | 100.0 |
| TOTAL TRACKS | | 244 | 209 | 183 | 202 | 194 | 217 | 214 | 192 | 197 | 178 |
| SCH/BCN CHANNELS | | B/B | B/B | A/A | A/B | A/B | A/B | A/B | A/A | B/A | B/B |

FIGURE D-2 DENVER ARTCC (ZDV) QARS DATA

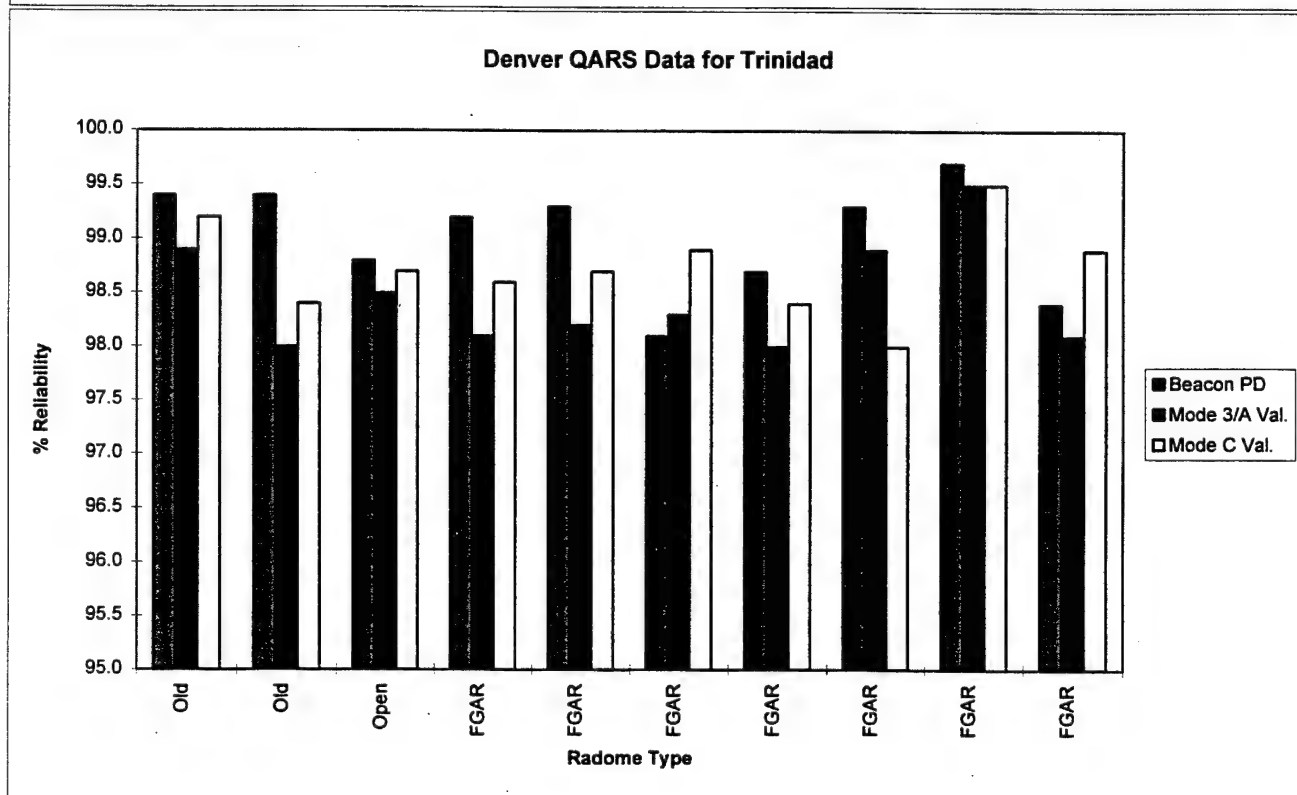
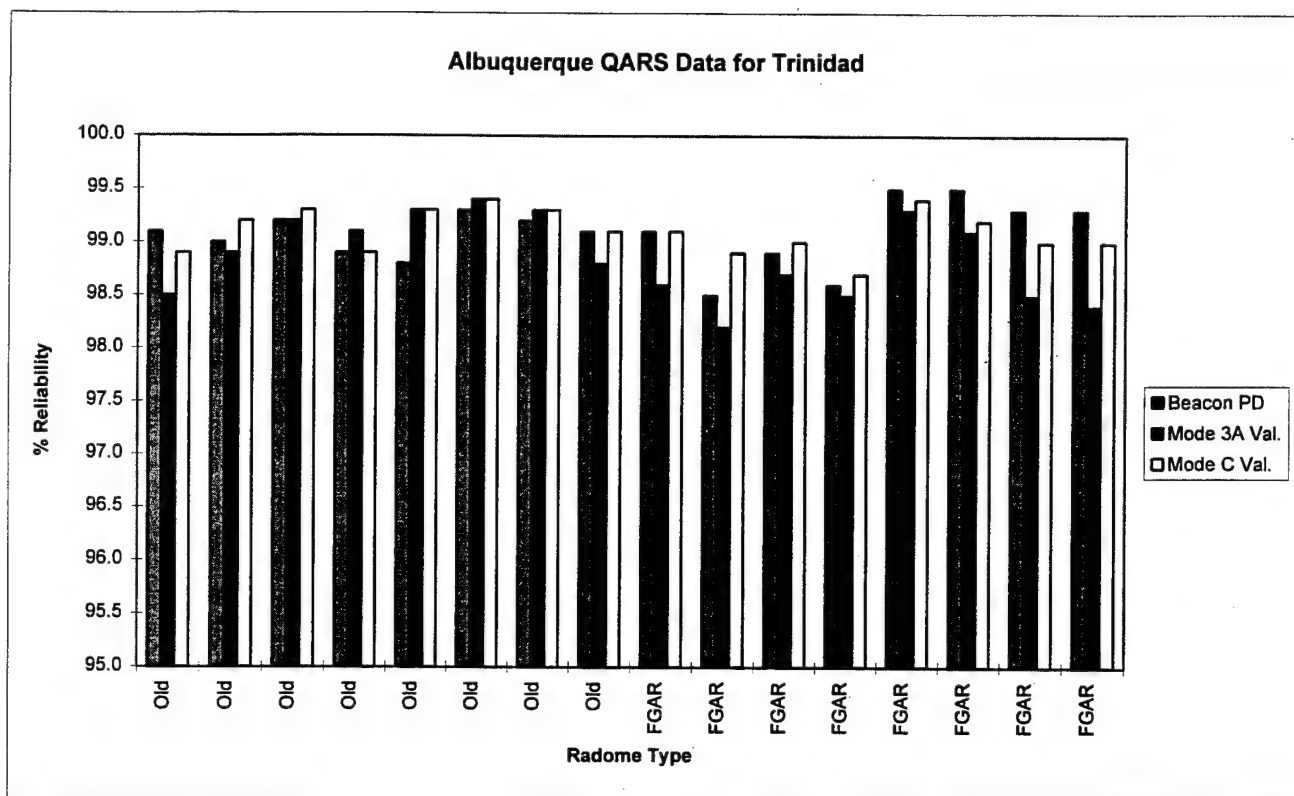


FIGURE D-3 QARS DATA GRAPHS

APPENDIX E

ATCS QUESTIONNAIRE RESPONSES

ALBUQUERQUE ARTCC (ZAB)

| ATCS EVALUATION QUESTIONS | | YES | NO | Number Not Responding | Percentage Of Favorable Responses |
|--|---|-----|----|-----------------------|-----------------------------------|
| PART I - PRIMARY (ARSR) RADAR EVALUATION | | | | | |
| 1. | Has the detection of primary targets changed, i.e., more or less: target drops, detection at various altitudes, less detection as target range increases? | 9 | 21 | 0 | 70.0 |
| 2. | Has the displayed primary track trajectories changed, i.e., track histories: are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan? | 9 | 21 | 0 | 70.0 |
| 3. | Has the number of primary false targets changed, i.e., false targets appearing more frequently or at undesirable locations? | 10 | 20 | 0 | 66.7 |
| 4. | Are the primary Permanent Echo's (PE) where they were before? | 25 | 2 | 3 | 92.6 |

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB)

| ATCS EVALUATION QUESTIONS | | YES | NO | Number Not Responding | Percentage Of Favorable Responses |
|---|--|-----|----|-----------------------|-----------------------------------|
| PART II - SECONDARY (BEACON) RADAR EVALUATION | | | | | |
| 1. | Has the detection of beacon targets changed, i.e., more or less: target drops, detection at various altitudes, less detection as target range increases? | 12 | 17 | 1 | 58.6 |
| 2. | Has the displayed beacon track trajectories changed, i.e., track histories: are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan? | 8 | 21 | 1 | 72.4 |
| 3. | Has the number of beacon false targets changed, i.e., target splits, code swaps, incorrect code changes, false targets appearing more frequently, or at undesirable locations? | 9 | 20 | 1 | 70.0 |
| 4. | Are you experiencing any beacon target ring-around <u>not</u> seen before? | 7 | 23 | 0 | 76.7 |
| 5. | Are the beacon Permanent Echo's (PE) where they were before? | 23 | 4 | 3 | 85.2 |
| 6. | Does the radar to beacon reinforcement appear the same? | 24 | 3 | 3 | 88.9 |

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB) [Continued]

| ATCS EVALUATION QUESTIONS | | YES | NO | Number Not Responding | Percentage Of Favorable Responses |
|-------------------------------|---|-----|----|-----------------------------|--|
| PART III - OVERALL EVALUATION | | | | | |
| 1. | Do you detect any degradation in the data displayed not experienced before? | 11 | 18 | 1 | 62.1 |
| 2. | Since the new radome has been installed, taking into account the limited time you have had in performing your air traffic control duties with the new radome, do you see or know of any reason why the FAA should not continue the replacement of en route radomes? | 6 | 20 | 4 | 76.9 |

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB) [Continued]

APPENDIX F

REPORT

MODE S TESTING

TECHNICAL CENTER'S ELWOOD ERBTF



U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: REPORT - FGAR Mode S OT&E Testing at the
Technical Center's Elwood ERBTF

Date: Jan 31, 1995

From: Andrew Leone, Mode S Engineer, ACW-100B

Reply to
Attn of

To: Associate Program Manager for Test (APMT), ACW-100B

1. INTRODUCTION.

Operational Test and Evaluation (OT&E) testing of the Fixed Ground Antenna Radome (FGAR) was performed at the FAA Technical Center's Elwood En Route Beacon Test Facility (ERBTF), during the period August 15 to December 6, 1994. The testing was performed using the Mode Select (Mode S) Beacon System in a beacon only configuration, since the Mode S-to-Common Digitizer (CD) -2 interface was not available. The Mode S software version used during the testing was a TR21.4 image modified to support the en route coverage map and dissemination format. In addition, CD-2 data were collected with the AN/UPX-27 beacon system and the Mode S operating in the Interim Beacon Initiative (IBI) configuration, with the Air Route Surveillance Radar (ARSR) -2.

Mode S data extraction data were analyzed using the Mode S Data Reduction (DR) program. The CD-2 format data were analyzed with the Radar Beacon Analysis Tool (RBAT) program.

A performance baseline was established with the Mode S by conducting a series of data collection runs with the inflatable radome, as well as two days without a radome installed. The analysis focused on (1) surveillance performance, (2) monopulse accuracy, (3) false target detection, (4) nine point track performance, and (5) fruit detection. These data verified proper system operation and provided a baseline to which the FGAR data could be compared.

2. TEST DESCRIPTIONS AND RESULTS.

The data collection runs were a minimum of 200 scans long and were usually performed in the morning between 0700 and 0900 local time. The last day of FGAR data collection followed two days of rain, and is labeled "FGAR Wet" on the figures and tables.

Mode S data collection via the Mode S Recording Display Equipment (MARDE), consisted of recording all: (1) interrogations, (2) target replies and reports, (3) surveillance track file data, and (4) dissemination data. In addition, CD-2 format dissemination data were collected at the Mode S modem ports using the Real-Time Analysis Display System (RTADS).

CD-2 output data were collected, at the RTADS, using the ARSR-2 together with either the Mode S operating in the IBI configuration or the AN/UPX-27 beacon system, as radar input. Due to problems in the ARSR-2 and CD-2, the data collected were marginal at best. However, the range and azimuth accuracy, when all systems were operating nominally, showed equivalent values with the inflatable radome and the FGAR.

Though data were collected with no radome installed, the analysis showed significantly larger errors, especially those relating to nine point azimuth accuracy. These errors can only be attributed to wind loading on the antennas. Due to the larger errors, these data have not been included in this report.

The following are the results and a discussion of the data analysis programs.

a. Beacon False Target Summary.

A comparison of the overall false target percentages demonstrated that the FGAR did not increase false target detection. The false target average decreased 0.15% after the FGAR was installed. Splits, uplink and downlink reflections, pulse repetition frequency (PRF), and ring-around percentages were all within nominal tolerances specified in Chapter 3, Standards and Tolerances, Order 6365.3, Maintenance of the Mode Select (Mode S) Beacon System.

Table 1 shows the summary data for the data collection runs. Figures 1 and 2 provide a graph of the false target and target split percentages, respectively. Each point on the X-axis represents a data collection run with a minimum of 200 scans of data.

b. Monopulse Analysis.

Monopulse accuracy was measured using the Mode S Calibration Performance Monitor Equipment (CPME). There was no degradation in azimuth accuracy across the beam with the FGAR detected. The Mode S maintained azimuth accuracy within $\pm 0.033^\circ$ (1.5 AU), as required by specification FAA-E-2716, Mode Select (Mode S) Beacon

System Sensor, with both the inflatable radome and the FGAR.

Figure 3 is a plot of the mean and standard deviation of the monopulse reply values versus the CPME's boresight azimuth. Figure 4 is a plot of the mean and standard deviation of the azimuth error versus the CPME's boresight azimuth. Figure 5 is a plot of absolute azimuth error versus the CPME's boresight azimuth. These plots were made with the inflatable radome installed. Figures 6 through 8 are similar plots with the FGAR installed.

c. Nine Point Analysis.

Summary totals for the nine point analysis program, using Mode S data extraction, was done as a broad gauge of overall tracking accuracy. The numbers used for comparison were the mean average of the standard deviation of error for all tracks within a given data collection run. Though the figures may appear to show poor overall tracking accuracy with respect to FAA-E-2716 requirements, particularly range errors, they are in fact biased due to a number of individual tracks. These tracks are either flying towards or away from the site, skirting the fringes of the beam, or performing turns, e.g., approaching or departing terminal sites. Therefore, these numbers can only be used for limited comparison. In general, range error decreased by 4.9%. However, azimuth errors increased by 1.5%, but were still within the 0.068° root-mean-square (RMS) accuracy required by specification FAA-E-2716.

Table 2 and figures 9 and 10 show the summary range and azimuth errors, for both Mode S and Air Traffic Control Radar Beacon System (ATCRBS) targets, for all of the data collection runs.

To eliminate fringe targets, a comparison was done at the dissemination level using the RBAT analysis package to filter the targets so that analysis could be performed on data within the main antenna beam coverage area. This area was defined as being within a range of 5 to 200 nautical miles (NM), 0 to 360° , between 5,000 and 50,000 feet, and with an elevation angle of 0.5° to 35° . This was done with the following sets of data: (1) Mode S, (2) CD-2 with Mode S operating in the IBI configuration, and (3) CD-2 with AN/UPX-27 beacon system data. The range and azimuth errors are greater than those derived from the Mode S data extract analysis, this is due to the coarser range and azimuth resolution within the message formats.

The FGAR improved the range error performance by the following:

- 1) Mode S - 0.3%
- 2) CD-2 with Mode S operating in the IBI configuration -1.1%
- 3) CD-2 with AN/UPX-27 beacon system - 1.1%

The azimuth error performance, with the FGAR installed, was varied:

- 1) Mode S - degraded 7.8%
- 2) CD-2 with Mode S operating in the IBI configuration - improved 7.8%
- 3) CD-2 with AN/UPX-27 beacon system - degraded 9.1%

Table 3 and figures 11 and 12 show the summary range and azimuth errors for all targets during the data collection runs.

To more accurately determine nine point accuracy, a select number of targets were analyzed. These targets were a mix of Mode S and ATCRBS tracks with a radial or tangential flight path. They were targets of high detection, code reliability, and code confidence. The data were filtered to eliminate targets ascending, descending, approaching or departing the antenna beam coverage area, and to eliminate any targets maneuvering within terminal areas. The results demonstrated an equivalent level of performance between the inflatable radome and FGAR. Tables 4 through 7 and figures 13 through 20 show the range and azimuth standard deviations for each selected target. The average errors of the selected tracks showed a slight decrease in the range error of 3.5%, with the FGAR installed. The azimuth error showed a degradation of 49%. Though the azimuth errors increased significantly with respect to the inflatable radome, the average azimuth error was still within the limits specified by FAA-E-2716.

Figures 21 and 22 are a plot of a selected Mode S and an ATCRBS track for the inflatable radome (Note: range rings are in 10 NM increments). Figures 23 and 24 are a plot of similar tracks for the FGAR. These plots provide a visual representation of the tracks as would be displayed on a Air Traffic Control Specialist (ATCS) display. They indicate there was no additional stitching of the tracks.

d. Surveillance Analysis.

The Mode S and ATCRBS overall probability of detection (PD), identification (ID) reliability and confidence, and the altitude reliability and confidence were acceptable. The FGAR did not significantly degrade performance in any category. The average:

- 1) PD increased 0.06%
- 2) ID reliability decreased 0.14%
- 3) ID confidence decreased 0.17%
- 4) Altitude reliability increased 0.31%
- 5) Altitude confidence increased 0.44%

Figure 25 shows the overall PD for each data collection run. Tables 8 through 10 and figures 26 through 33 show the overall PD, code reliability and confidence, and altitude reliability and confidence for Mode S and ATCRBS targets.

e. Fruit Analysis.

The average levels of Mode S and ATCRBS fruit decreased after the FGAR was installed. Mode S fruit decreased approximately 22% and ATCRBS fruit decreased approximately 5%. Table 11 and Figure 34 show the fruit levels detected for each data collection run.

3. CONCLUSIONS.

The Mode S surveillance performance tests indicated the quality and accuracy of the data provided by the Mode S with the FGAR installed has not been significantly improved or degraded, when compared to the inflatable radome.

If you have any questions, contact Andrew Leone, at (609) 485-5578.



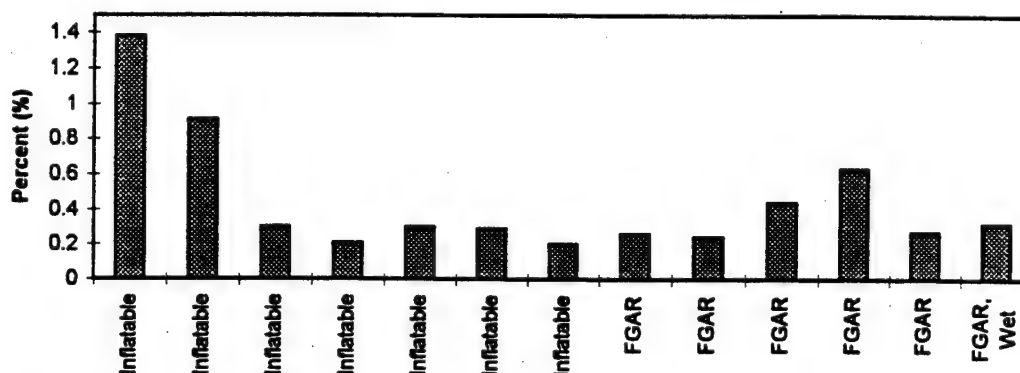
Andrew Leone
Mode S Engineer, ACW-100B

Enclosures

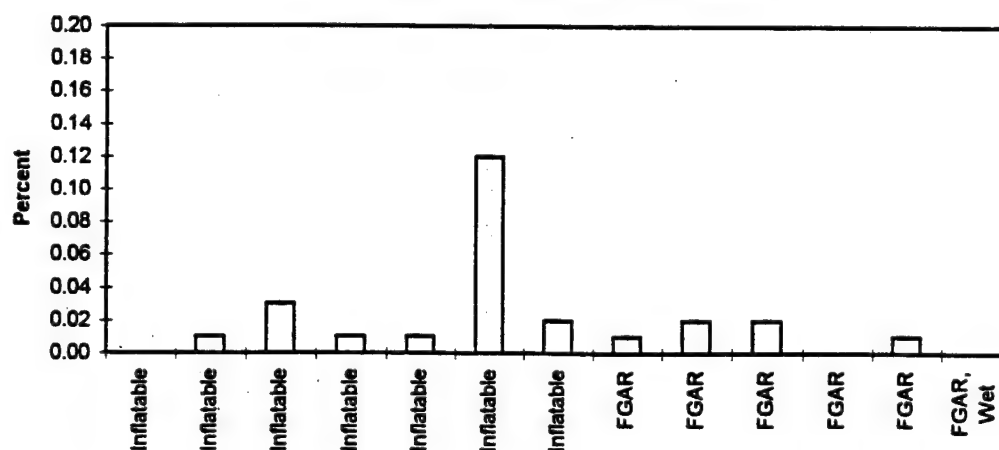
TABLE 1

| | | Total | Total | False | Split | | Ringaround | | Down Refl. | | PRF | | Up Refl. | | Other | |
|------------|----------|------------------|----------|-------|-------|------|------------|------|------------|------|------|------|----------|------|-------|------|
| | | False Tgts | Tgt Rpts | Tgt % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| | | Nominal Limits → | | | <0.2 | | <1.0 | | <1.0 | | <1.0 | | <1.0 | | | |
| Inflatable | 9/12/94 | 841 | 60839 | 1.38 | 2 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 6 | 0.01 | 502 | 0.70 |
| Inflatable | 9/13/94 | 624 | 68949 | 0.91 | 10 | 0.01 | 0 | 0.00 | 1 | 0.00 | 3 | 0.00 | 0 | 0.00 | 405 | 0.00 |
| Inflatable | 9/14/94 | 195 | 65210 | 0.3 | 19 | 0.03 | 0 | 0.00 | 1 | 0.00 | 2 | 0.00 | 0 | 0.00 | 140 | 0.20 |
| Inflatable | 9/15/94 | 109 | 51996 | 0.21 | 6 | 0.01 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 5 | 0.01 |
| Inflatable | 9/16/94 | 174 | 58588 | 0.3 | 8 | 0.01 | 0 | 0.00 | 0 | 0.00 | 1 | 0.00 | 2 | 0.00 | 120 | 0.20 |
| Inflatable | 9/19/94 | 172 | 58924 | 0.29 | 78 | 0.12 | 0 | 0.00 | 0 | 0.00 | 1 | 0.00 | 0 | 0.00 | 7 | 0.01 |
| Inflatable | 9/20/94 | 114 | 56038 | 0.2 | 11 | 0.02 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 13 | 0.02 |
| FGAR | 10/17/94 | 196 | 76512 | 0.26 | 10 | 0.01 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 2 | 0.00 | 94 | 0.11 |
| FGAR | 10/18/94 | 131 | 55718 | 0.24 | 13 | 0.02 | 1 | 0.00 | 0 | 0.00 | 4 | 0.01 | 2 | 0.00 | 14 | 0.02 |
| FGAR | 10/19/94 | 317 | 71705 | 0.44 | 20 | 0.02 | 0 | 0.00 | 1 | 0.00 | 24 | 0.03 | 4 | 0.00 | 126 | 0.16 |
| FGAR | 10/20/94 | 290 | 46328 | 0.63 | 2 | 0.00 | 0 | 0.00 | 0 | 0.00 | 4 | 0.01 | 0 | 0.00 | 277 | 0.56 |
| FGAR | 10/21/94 | 146 | 53163 | 0.27 | 6 | 0.01 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 79 | 0.14 |
| FGAR, Wet | 12/6/94 | 187 | 58914 | 0.32 | 1 | 0.00 | 0 | 0.00 | 3 | 0.00 | 0 | 0.00 | 0 | 0.00 | 105 | 0.16 |

Total Beacon False Target Percentage



Beacon False Tgt Summary, Splits



FIGURES 1 & 2

Fixed Transponder
 ATCRBS id=0206
 Mode S id=adf7ca
 Range=1939 RUs
 Azimuth=7162 AUs

Filters
 Scan: 0,65535
 00:00:00,48:00:00
 ATCRBS and Mode S
 Beamwidth = 169 AUs
 Points = 170
 +- 81.0

Mean and Standard Deviation Plot
 Mode S Sensor 136
 Fri Aug 26 09:24:19 1994
 Extraction Day/Time: 238/08:06:41

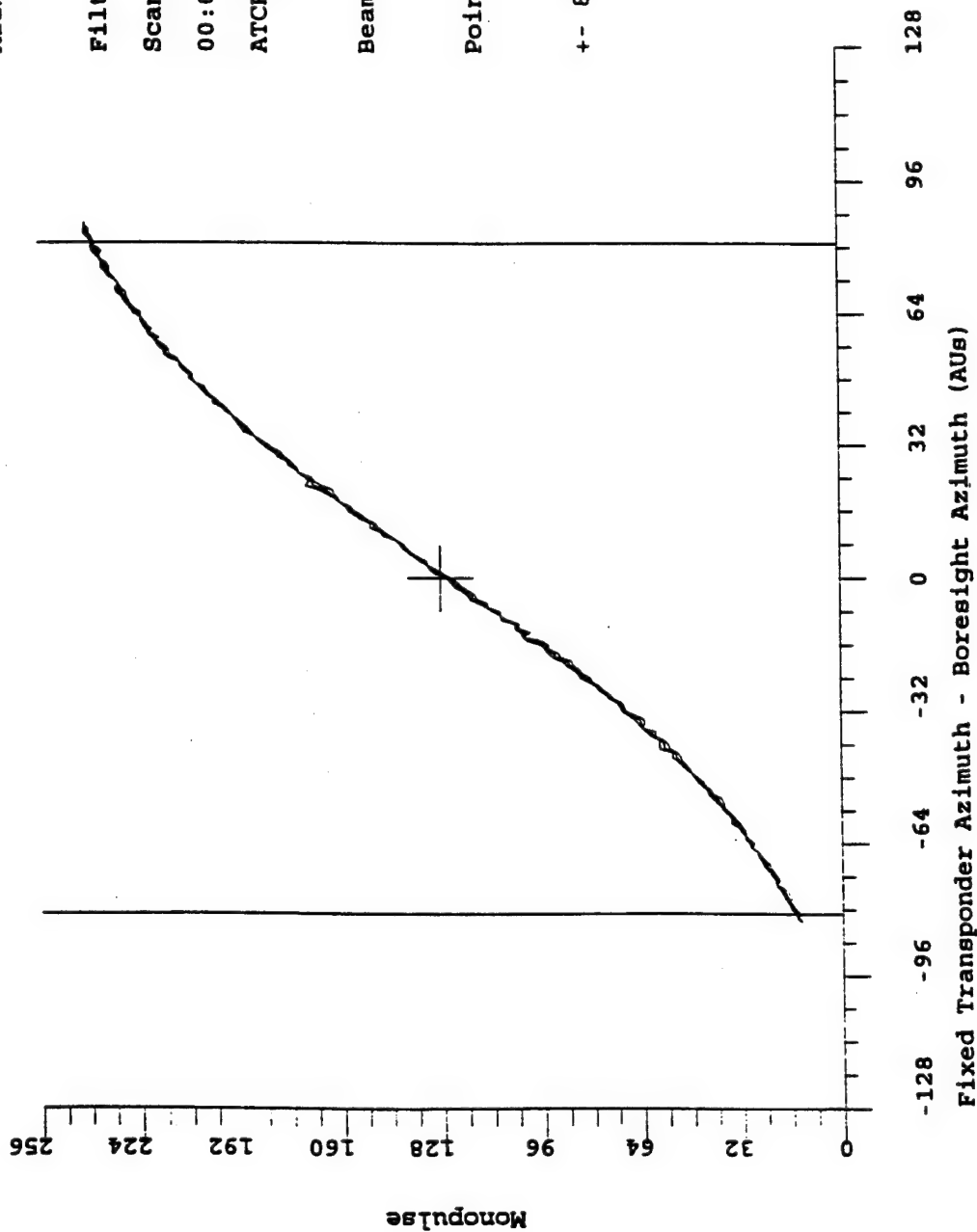


FIGURE 3

Mean and Standard Deviation Plot

Mode S Sensor 136

Fri Aug 26 09:24:19 1994

Extraction Day/Time: 238/08:06:41

Fixed Transponder

ATCRBS id=0206

Mode S id=adf7ca

Range=1939 RUs

Azimuth=7162 AUs

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 169 AUs

Points = 170

+ - 81.0

+ - 2.5

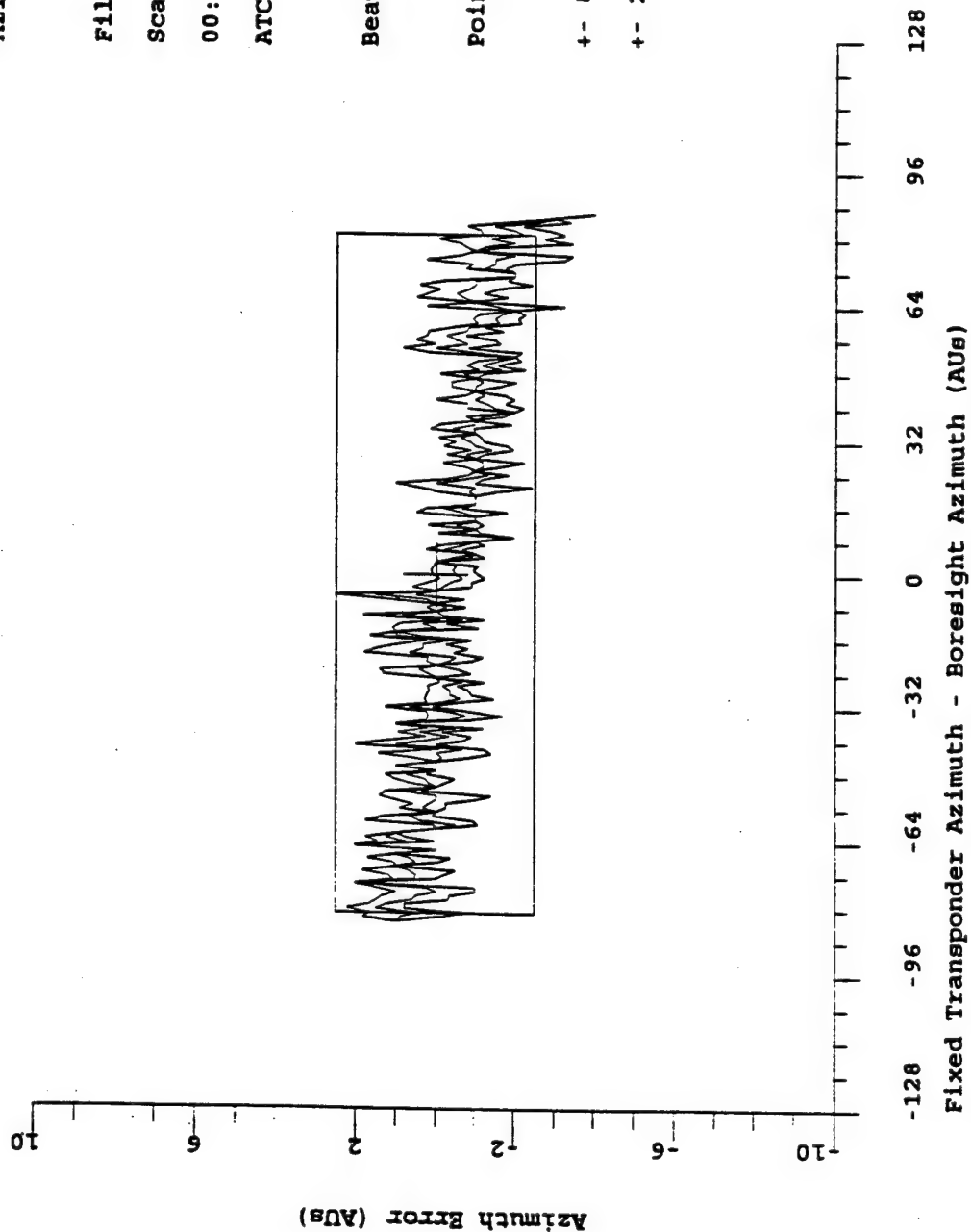


FIGURE 4

Fixed Transponder
 ATCRBS id=0206
 Mode S id=adf7ca
 Range=1939 RUs
 Azimuth=7162 AUs

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 169 AUs

Points = 170

+ - 81.0

+ - 2.5

Mean Plot

Mode S Sensor 136

Fri Aug 26 09:24:19 1994

Extraction Day/Time: 238/08:06:41

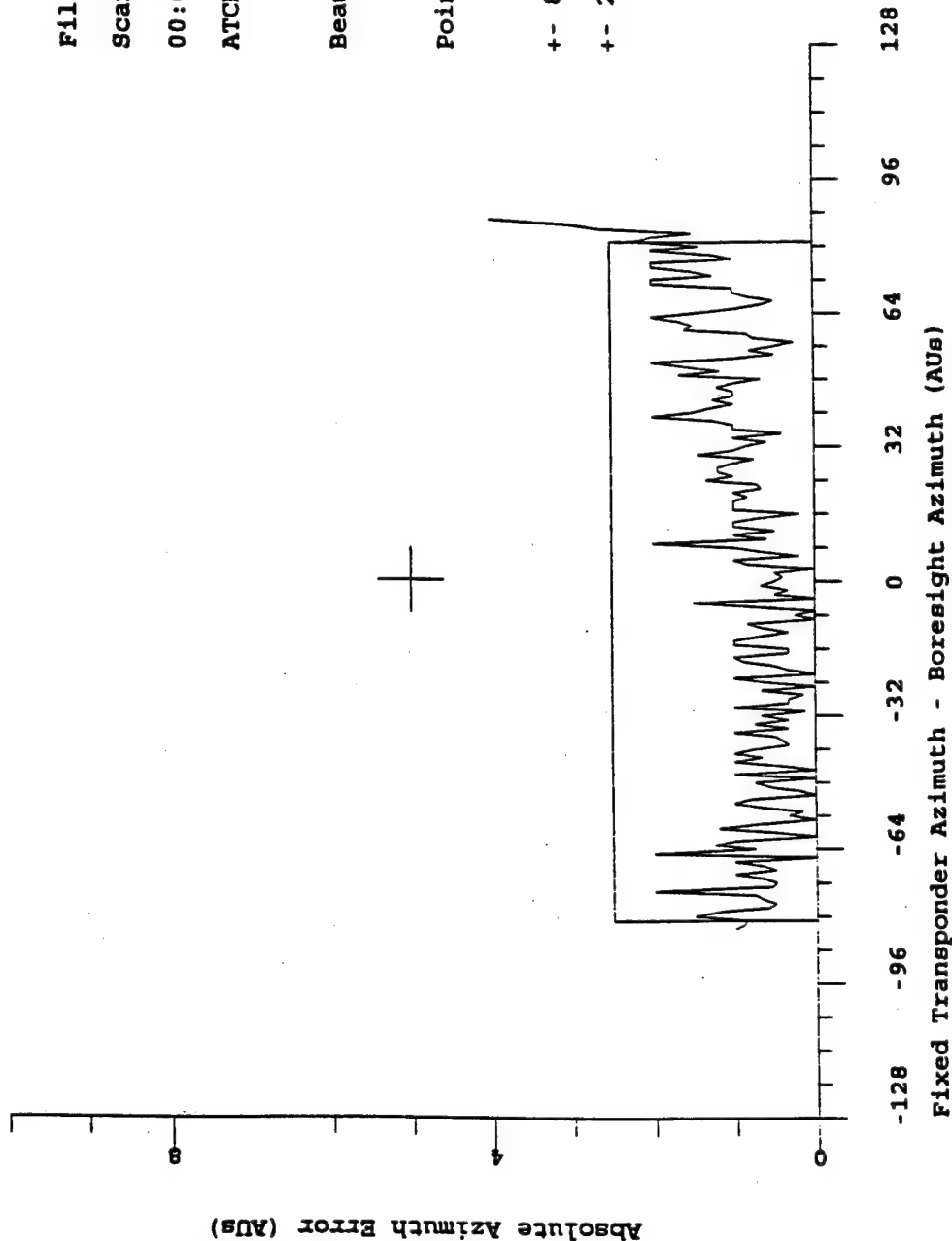


FIGURE 5

Mean and Standard Deviation Plot

Mode S Sensor 136

Tue Dec 6 13:32:57 1994

Extraction Day/Time: 340/07:52:41

Fixed Transponder

ATCRBS id=0207

Mode S id=adfa16

Range=9856 RUs

Azimuth=9271 AU's

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 178 AU's

Points = 177

+ - 81.0

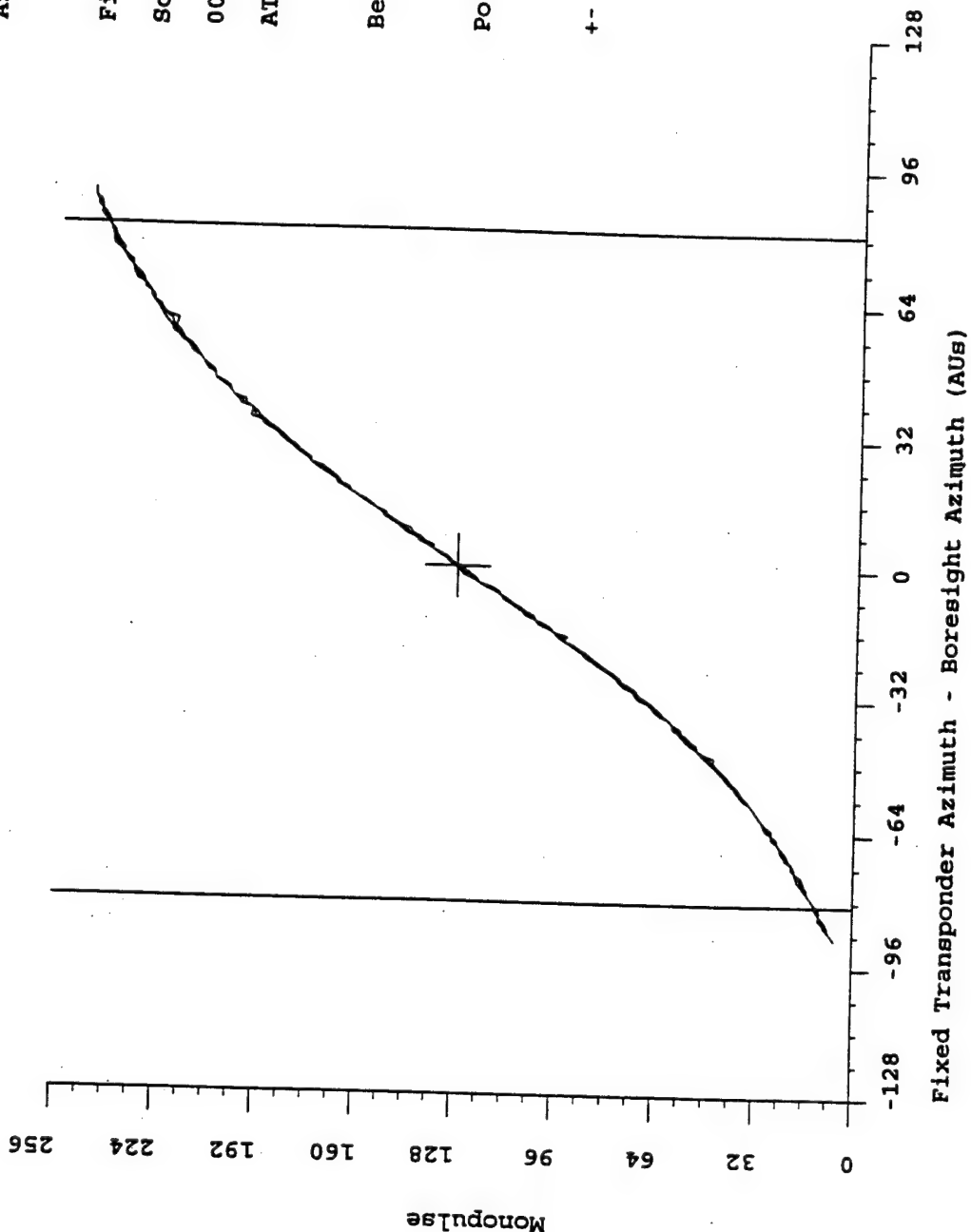


FIGURE 6

Mean and Standard Deviation Plot

Mode S Sensor 136

Tue Dec 6 13:32:57 1994

Extraction Day/Time: 340/07:52:41

Fixed Transponder

ATCRBS id=0207

Mode S id=adfa16

Range=9856 RUs

Azimuth=9271 AUs

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 178 AUs

Points = 177

+ - 81.0

+ - 2.5

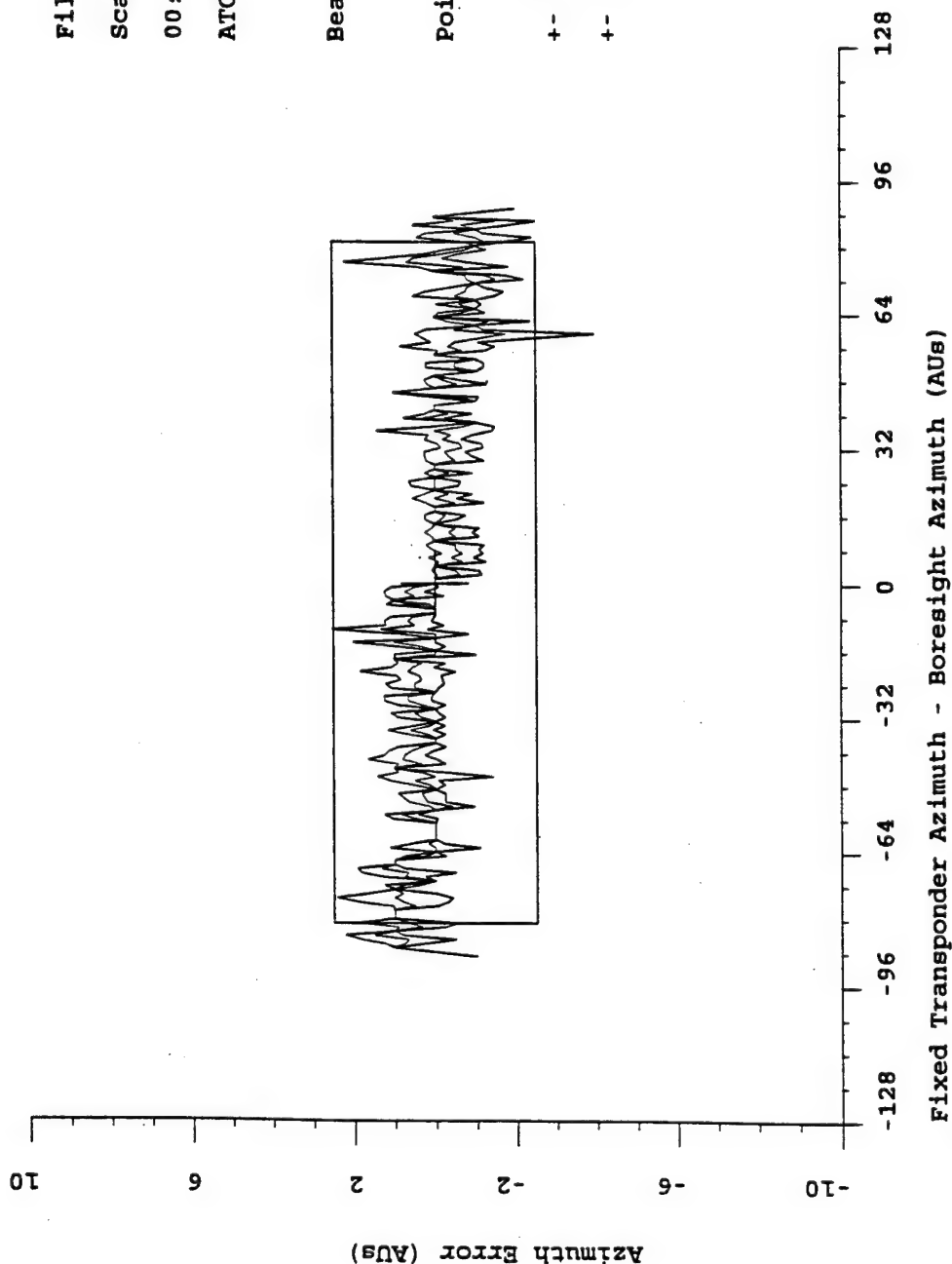


FIGURE 7

Mean Plot

Mode S Sensor 136

Tue Dec 6 13:32:57 1994

Extraction Day/Time: 340/07:52:41

Fixed Transponder

ATCRBS id=0207

Mode S id=adfa16

Range=9856 RUS

Azimuth=9271 AUs

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 178 AUs

Points = 177

+ - 81.0

+ - 2.5

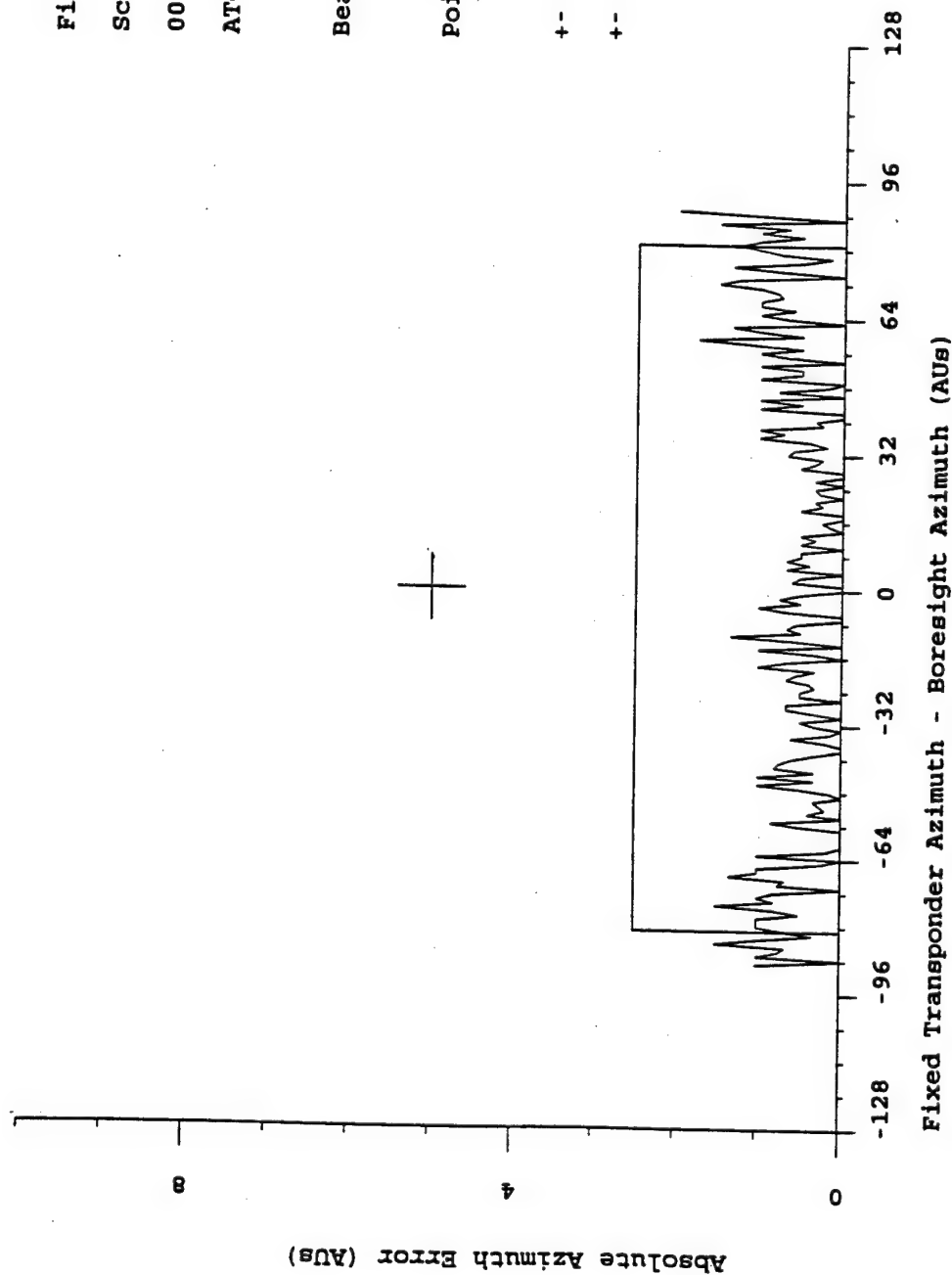
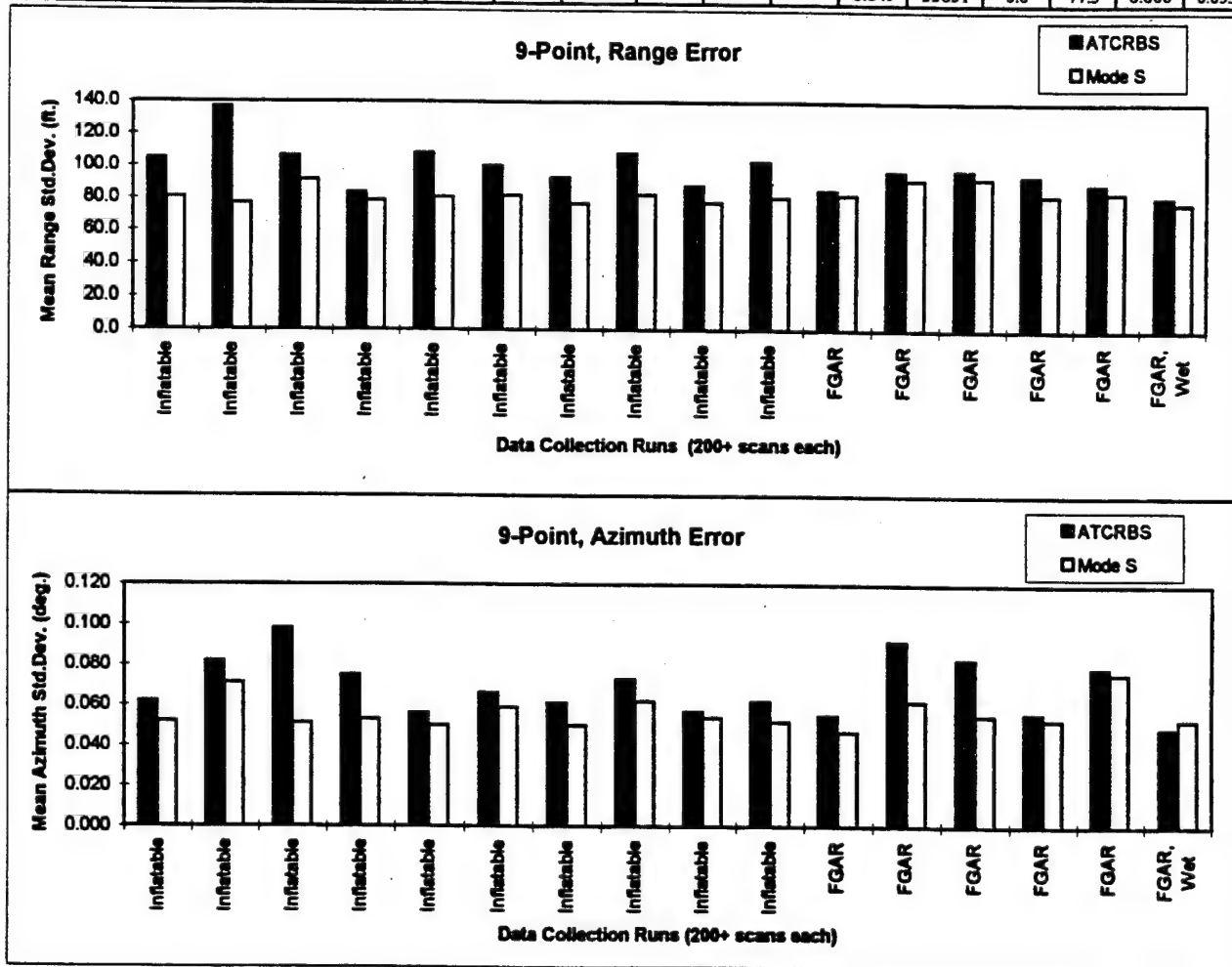


FIGURE 8

TABLE 2

| | Date | Total | | | | | ATCRBS | | | | | Mode S | | | | |
|------------|----------|-------------|-----------------|--------|------------------|--------|-------------|-----------------|--------|------------------|--------|-------------|-----------------|--------|------------------|--------|
| | | Sample Size | Rg. Error (ft.) | | Az. Error (deg.) | | Sample Size | Rg. Error (ft.) | | Az. Error (deg.) | | Sample Size | Rg. Error (ft.) | | Az. Error (deg.) | |
| | | | Mean | StdDev | Mean | StdDev | | Mean | StdDev | Mean | StdDev | | Mean | StdDev | Mean | StdDev |
| Inflatable | 9/12/94 | 86390 | 0.0 | 93.1 | 0.000 | 0.037 | 42669 | 0.0 | 104.3 | 0.000 | 0.062 | 43721 | 0.0 | 80.6 | 0.000 | 0.052 |
| Inflatable | 9/13/94 | 90187 | -0.2 | 111.6 | 0.000 | 0.076 | 46005 | -0.5 | 137.0 | 0.000 | 0.082 | 44182 | 0.1 | 76.6 | 0.000 | 0.071 |
| Inflatable | 9/14/94 | 87565 | -0.3 | 99.3 | 0.000 | 0.079 | 45706 | -0.6 | 106.0 | 0.000 | 0.098 | 41859 | -0.1 | 91.4 | 0.000 | 0.051 |
| Inflatable | 9/15/94 | 72758 | -0.1 | 80.9 | 0.000 | 0.065 | 37158 | -0.4 | 83.2 | 0.000 | 0.075 | 35600 | 0.0 | 78.4 | 0.000 | 0.053 |
| Inflatable | 9/16/94 | 80352 | -0.2 | 95.8 | 0.000 | 0.053 | 41918 | -0.3 | 107.8 | 0.000 | 0.056 | 38434 | 0.0 | 80.7 | 0.000 | 0.050 |
| Inflatable | 9/19/94 | 78756 | 0.0 | 90.8 | 0.000 | 0.062 | 37949 | 0.0 | 99.9 | 0.000 | 0.066 | 40807 | -0.1 | 81.5 | 0.000 | 0.059 |
| Inflatable | 9/20/94 | 72467 | -0.2 | 85.3 | 0.000 | 0.056 | 37296 | -0.2 | 92.8 | 0.000 | 0.061 | 35171 | -0.1 | 76.7 | 0.000 | 0.050 |
| Inflatable | 9/21/94 | 62675 | -0.3 | 96.0 | 0.000 | 0.068 | 31726 | -0.6 | 107.8 | 0.000 | 0.073 | 30949 | 0.0 | 82.3 | 0.000 | 0.062 |
| Inflatable | 9/22/94 | 62218 | 0.0 | 82.6 | 0.000 | 0.056 | 30159 | 0.0 | 87.9 | 0.000 | 0.057 | 32059 | 0.0 | 77.3 | 0.000 | 0.054 |
| Inflatable | 9/23/94 | 68796 | 0.0 | 91.3 | 0.000 | 0.057 | 31763 | 0.0 | 102.5 | 0.000 | 0.062 | 37033 | 0.0 | 80.4 | 0.000 | 0.052 |
| FGAR | 10/17/94 | 108250 | 0.0 | 83.7 | 0.000 | 0.052 | 54319 | -0.2 | 84.9 | 0.000 | 0.055 | 53931 | 0.2 | 82.4 | 0.000 | 0.047 |
| FGAR | 10/18/94 | 70806 | -0.1 | 94.2 | 0.000 | 0.078 | 35123 | -0.1 | 96.7 | 0.000 | 0.092 | 35683 | -0.1 | 91.7 | 0.000 | 0.062 |
| FGAR | 10/19/94 | 86894 | -0.3 | 95.3 | 0.000 | 0.070 | 42773 | -0.5 | 97.8 | 0.000 | 0.083 | 44121 | -0.1 | 92.8 | 0.000 | 0.055 |
| FGAR | 10/20/94 | 65954 | -0.3 | 89.1 | 0.000 | 0.055 | 36862 | -0.4 | 94.1 | 0.000 | 0.056 | 29092 | 0.1 | 82.3 | 0.000 | 0.053 |
| FGAR | 10/21/94 | 80616 | 0.1 | 86.7 | 0.000 | 0.077 | 41225 | 0.0 | 89.3 | 0.000 | 0.079 | 39391 | 0.2 | 83.9 | 0.000 | 0.076 |
| FGAR, Wet | 12/6/94 | 79316 | -0.3 | 79.6 | 0.000 | 0.051 | 43465 | -0.5 | 81.4 | 0.000 | 0.049 | 35851 | 0.0 | 77.3 | 0.000 | 0.053 |



FIGURES 9 & 10

| | Range Error (nm.) | | | Azimuth Error (deg.) | | |
|------------|-------------------|--------|--------|----------------------|--------|--------|
| | Mode S | IBI | UPX-27 | Mode S | IBI | UPX-27 |
| Inflatable | 0.0440 | 0.0446 | 0.0440 | 0.0515 | 0.1697 | 0.1422 |
| Inflatable | 0.0438 | 0.0449 | 0.0451 | 0.0532 | 0.1481 | 0.1420 |
| FGAR | 0.0439 | 0.0438 | 0.0441 | 0.0619 | 0.1575 | 0.1577 |
| FGAR | 0.0436 | 0.0438 | 0.0440 | 0.0510 | 0.1354 | 0.1524 |

TABLE 3

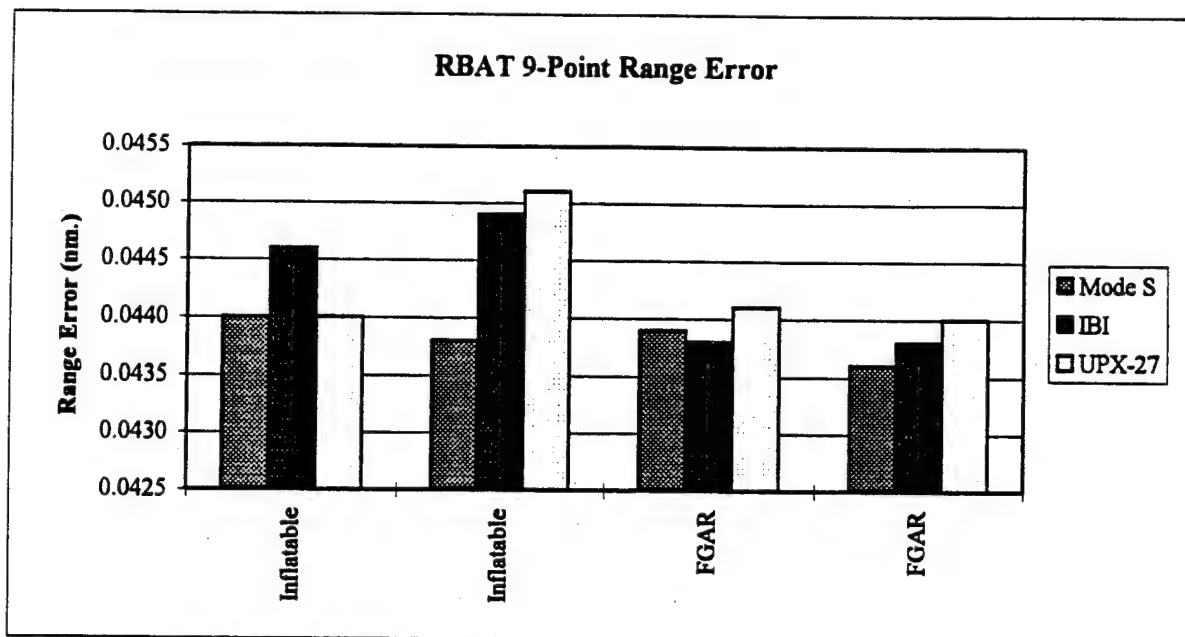


FIGURE 11

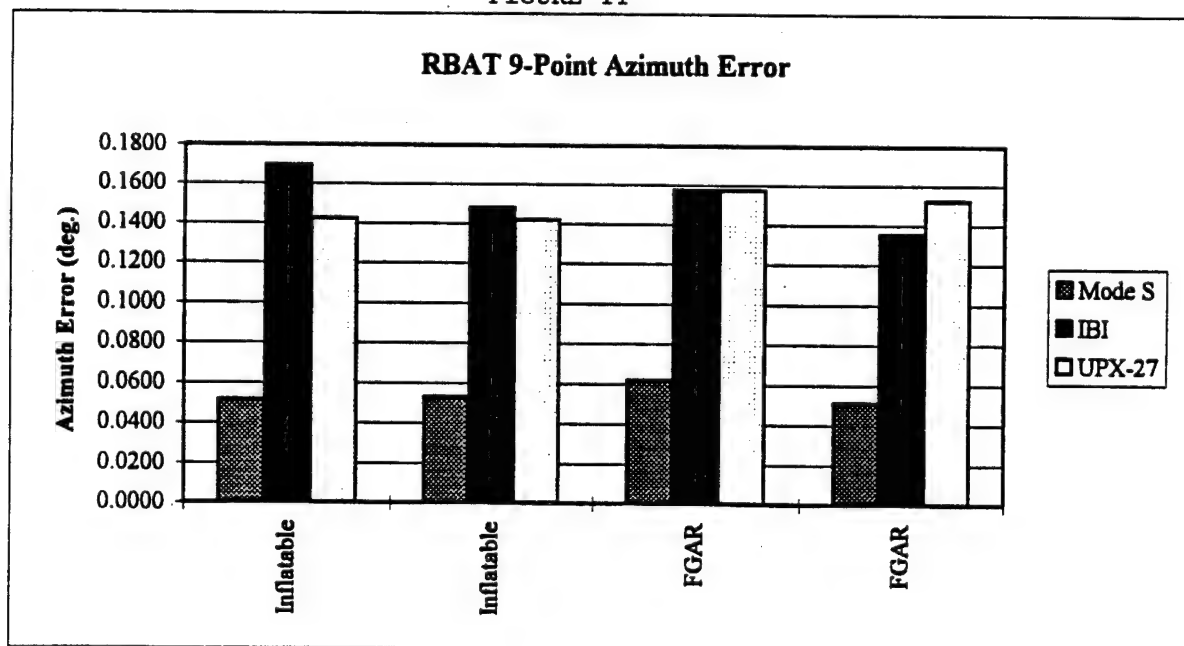


FIGURE 12

| | Inlitable | Inlitable | Inlitable | Inlitable | Inlitable | FOAR | FOAR | FOAR | FOAR |
|----------------------------|-----------|-----------|-----------|-----------|-----------|---------|---------|---------|---------|
| Track No. (SFN) | 423 | 194 | 104 | 555 | 242 | 9 | 264 | 256 | 63 |
| Mode 3/A | 3162 | 2015 | 3341 | 0522 | 0510 | 3073 | 1437 | 1624 | 7367 |
| Mode S Id | a648df | a2867e | a828d1 | aeb86a | a0b77c | a08a0e | ae7292 | a07522 | a00676 |
| Mode S/ATCRBS (S/A) | S | S | S | S | S | S | S | S | S |
| Radial/Tangential (R/T) | T | T | T | T | T | T | T | T | T |
| Range (nm) | 176-54 | 102-87 | 81-175 | 120-67 | 54-84 | 107-200 | 145-76 | 81-200 | 140-121 |
| Azimuth (deg.) | 232-24 | 23-255 | 12-262 | 203-43 | 236-18 | 81-132 | 56-195 | 58-133 | 24-272 |
| Altitude (100s ft.) | 370-69 | 350-24 | 130-390 | 370-21 | 240-35 | 209-330 | 350-350 | 143-354 | 245-100 |
| Scans | 206 | 120 | 207 | 194 | 194 | 114 | 168 | 112 | 203 |
| PD | 100.00 | 100.00 | 100.00 | 99.48 | 100.00 | 98.25 | 100.00 | 100.00 | 100.00 |
| ID Rel. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Alt. Rel. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.91 | 100.00 | 100.00 |
| RpyRpt | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9point Range Mean (ft.) | 0.0 | -0.1 | -0.1 | -1.6 | 0.1 | 0.4 | 0.0 | -0.8 | -0.4 |
| 9point Range SD (ft.) | 21.8 | 62.7 | 49.2 | 69.2 | 49.5 | 39.4 | 17.9 | 35.2 | 26.6 |
| 9point Azimuth Mean (deg.) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9point Azimuth SD (deg.) | 0.031 | 0.032 | 0.032 | 0.034 | 0.031 | 0.058 | 0.081 | 0.062 | 0.037 |

| | Inlitable | Inlitable | Inlitable | Inlitable | Inlitable | FOAR | FOAR | FOAR | FOAR | FOAR | FOAR |
|----------------------------|-----------|-----------|-----------|-----------|-----------|---------|---------|---------|---------|---------|--------|
| Track No. (SFN) | 110 | 114 | 20 | 405 | 647 | 72 | 196 | 358 | 466 | 18 | 445 |
| Mode 3/A | 7374 | 2756 | 7355 | 5736 | 3542 | 1673 | 2776 | 3460 | 6714 | 1631 | 0503 |
| Mode S Id | a057b9 | a0aa6d | ab1654 | a12ae7 | a0ccca | a975fe | aa2ba7 | aaed1c | ed2b36 | ac6621 | a2aa46 |
| Mode S/ATCRBS (S/A) | S | S | S | S | S | S | S | S | S | S | S |
| Radial/Tangential (R/T) | R | R | R | R | R | R | R | R | R | R | R |
| Range (nm) | 31-200 | 25-140 | 38-117 | 200-27 | 155-199 | 35-199 | 128-200 | 115-199 | 197-61 | 77-200 | 93-65 |
| Azimuth (deg.) | 89-207 | 181-205 | 193-252 | 284-312 | 9-322 | 238-132 | 350-329 | 323-287 | 301-353 | 286-277 | 228-20 |
| Altitude (100s ft.) | 390-390 | 180-180 | 188-61 | 270-11 | 350-350 | 240-35 | 279-280 | 350-350 | 370-109 | 210-309 | 313-17 |
| Scans | 194 | 207 | 126 | 199 | 121 | 167 | 84 | 120 | 135 | 113 | 169 |
| PD | 98.97 | 98.07 | 100.00 | 100.00 | 100.00 | 99.40 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| ID Rel. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Alt. Rel. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.26 | 100.00 | 100.00 |
| RpyRpt | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9point Range Mean (ft.) | -0.1 | -0.1 | -0.2 | 0.1 | 0.0 | 4.1 | 0.7 | -3.3 | -0.1 | -0.3 | -0.4 |
| 9point Range SD (ft.) | 19.0 | 25.8 | 74.5 | 89.1 | 45.4 | 56.4 | 36.0 | 41.9 | 76.2 | 41.5 | 47.4 |
| 9point Azimuth Mean (deg.) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | -0.001 | -0.001 | 0.000 | 0.000 | 0.000 |
| 9point Azimuth SD (deg.) | 0.029 | 0.030 | 0.042 | 0.047 | 0.046 | 0.037 | 0.062 | 0.032 | 0.043 | 0.039 | 0.031 |

| | Inlitable | Inlitable | Inlitable | Inlitable | FOAR | FOAR | FOAR | FOAR | FOAR | FOAR |
|----------------------------|-----------|-----------|-----------|-----------|---------|---------|---------|--------|---------|---------|
| Track No. (SFN) | 722 | 759 | 107 | 724 | 761 | 197 | 490 | 452 | 188 | 9 |
| Mode 3/A | 1740 | 3067 | 1777 | 2676 | 1442 | 3007 | 2663 | 0547 | 7312 | 3501 |
| Mode S/ATCRBS (S/A) | A | A | A | A | A | A | A | A | A | A |
| Radial/Tangential (R/T) | T | T | T | T | T | T | T | T | T | T |
| Range (nm) | 41-147 | 79-93 | 43-169 | 199-84 | 88-123 | 174-200 | 124-122 | 83-79 | 85-91 | 130-112 |
| Azimuth (deg.) | 331-207 | 37-263 | 86-204 | 314-4 | 52-203 | 319-278 | 327-2 | 246-50 | 61-238 | 341-275 |
| Altitude (100s ft.) | 6-280 | 30-349 | 234-996 | 370-36 | 326-431 | 208-390 | 70-70 | 170 | 280-100 | 160-99 |
| Scans | 181 | 172 | 205 | 135 | 167 | 134 | 147 | 182 | 81 | 203 |
| PD | 99.45 | 99.42 | 99.02 | 97.78 | 100.00 | 89.55 | 95.24 | 100.00 | 100.00 | 100.00 |
| ID Rel. | 98.89 | 99.42 | 92.12 | 93.18 | 100.00 | 97.50 | 96.43 | 99.45 | 100.00 | 98.52 |
| ID Val. | 99.44 | 98.83 | 91.63 | 87.12 | 100.00 | 95.00 | 93.57 | 98.90 | 100.00 | 98.03 |
| Alt. Rel. | 98.33 | 98.83 | 91.63 | 93.94 | 100.00 | 95.00 | 97.14 | 99.45 | 98.51 | 98.03 |
| Alt. Val. | 95.56 | 95.91 | 85.22 | 84.09 | 99.40 | 92.50 | 91.43 | 96.70 | 96.53 | 94.09 |
| RpyRpt | 5.6 | 5.8 | 5.5 | 5.1 | 6.3 | 4.6 | 5 | 5.4 | 6.3 | 5.7 |
| 9point Range Mean (ft.) | -7.3 | 2.8 | 0.5 | -2.8 | -0.3 | -2.7 | -1.2 | 0.5 | 0.1 | -0.6 |
| 9point Range SD (ft.) | 80.5 | 72.8 | 39.5 | 21.4 | 24.5 | 32.3 | 32.7 | 34.5 | 75.5 | 42.9 |
| 9point Azimuth Mean (deg.) | 0.001 | 0.001 | 0.001 | -0.002 | -0.003 | 0.001 | 0.003 | 0.000 | 0.002 | 0.000 |
| 9point Azimuth SD (deg.) | 0.043 | 0.020 | 0.042 | 0.072 | 0.088 | 0.061 | 0.044 | 0.087 | 0.042 | 0.050 |

| | Inlitable | Inlitable | Inlitable | Inlitable | Inlitable | FOAR | FOAR | FOAR | FOAR | FOAR |
|----------------------------|-----------|-----------|-----------|-----------|-----------|---------|---------|---------|---------|---------|
| Track No. (SFN) | 154 | 195 | 528 | 202 | 640 | 561 | 652 | 614 | 157 | 203 |
| Mode 3/A | 0533 | 3465 | 2030 | 3073 | 5132 | 3050 | 6031 | 6564 | 1706 | 5514 |
| Mode S/ATCRBS (S/A) | A | A | A | A | A | A | A | A | A | A |
| Radial/Tangential (R/T) | R | R | R | R | R | R | R | R | R | R |
| Range (nm) | 45-143 | 25-116 | 157-14 | 23-102 | 89-83 | 5-123 | 161-33 | 112-89 | 36-189 | 70-128 |
| Azimuth (deg.) | 73-53 | 203-226 | 42-294 | 211-207 | 262-16 | 253-210 | 298-335 | 210-44 | 240-210 | 315-259 |
| Altitude (100s ft.) | 210-116 | 159-159 | 159-59 | 60-60 | 57-175 | 217-348 | 268-2 | 293-158 | 172-227 | 100-165 |
| Scans | 118 | 207 | 206 | 207 | 205 | 81 | 165 | 169 | 68 | 203 |
| PD | 97.46 | 99.52 | 95.63 | 98.55 | 99.51 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| ID Rel. | 99.13 | 97.57 | 98.98 | 98.53 | 99.02 | 100.00 | 98.18 | 100.00 | 100.00 | 97.54 |
| ID Val. | 99.13 | 96.60 | 99.49 | 97.06 | 98.04 | 100.00 | 98.18 | 100.00 | 100.00 | 98.03 |
| Alt. Rel. | 99.13 | 97.09 | 98.48 | 100.00 | 98.04 | 100.00 | 96.97 | 100.00 | 98.77 | 95.07 |
| Alt. Val. | 93.91 | 91.26 | 94.42 | 95.10 | 96.57 | 98.31 | 93.33 | 99.41 | 98.16 | 93.60 |
| RpyRpt | 5.9 | 5.6 | 6 | 6.2 | 5.9 | 5.6 | 5.9 | 6.2 | 5.9 | 5.6 |
| 9point Range Mean (ft.) | 0.0 | -0.2 | -0.4 | -0.5 | 1.0 | 4.0 | 0.0 | -5.5 | -0.1 | 0.5 |
| 9point Range SD (ft.) | 29.2 | 23.9 | 47.9 | 19.6 | 40.7 | 36.8 | 50.8 | 65.8 | 40.2 | 20.6 |
| 9point Azimuth Mean (deg.) | 0.000 | 0.000 | 0.002 | 0.001 | 0.002 | 0.003 | 0.000 | 0.001 | 0.000 | 0.002 |
| 9point Azimuth SD (deg.) | 0.036 | 0.040 | 0.046 | 0.032 | 0.048 | 0.036 | 0.079 | 0.067 | 0.067 | 0.045 |

TABLES 4/5/6/7

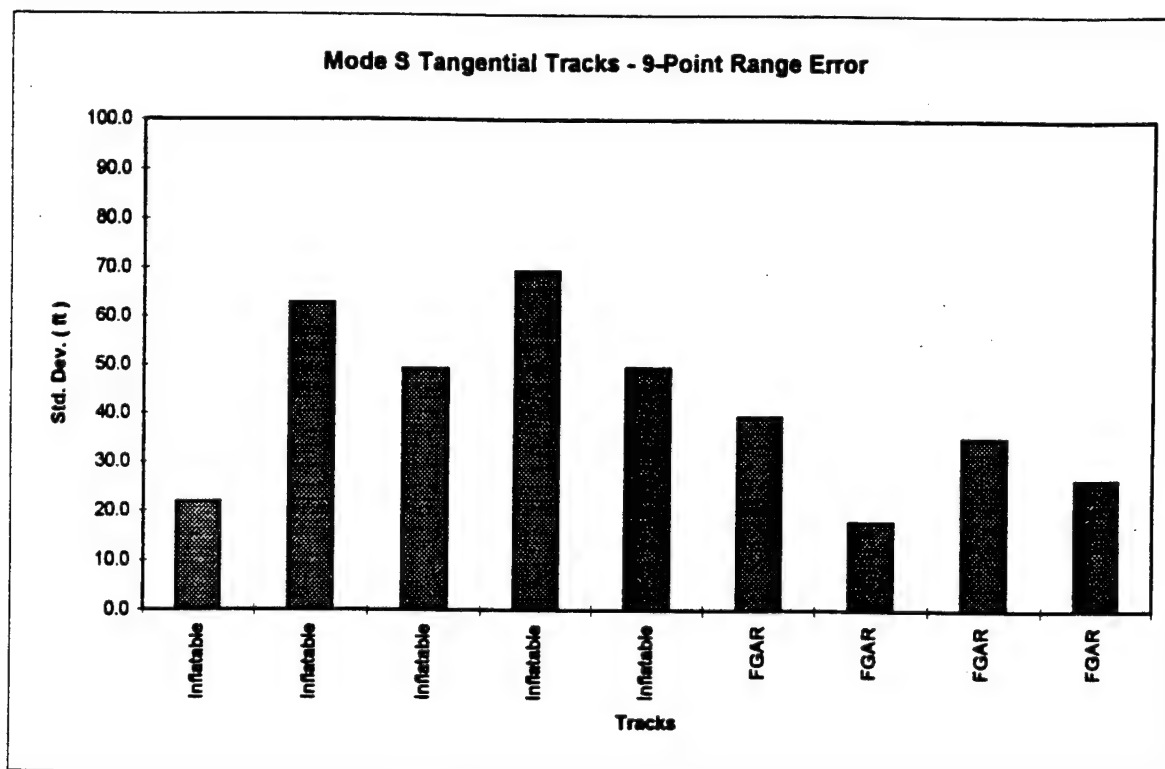


FIGURE 13

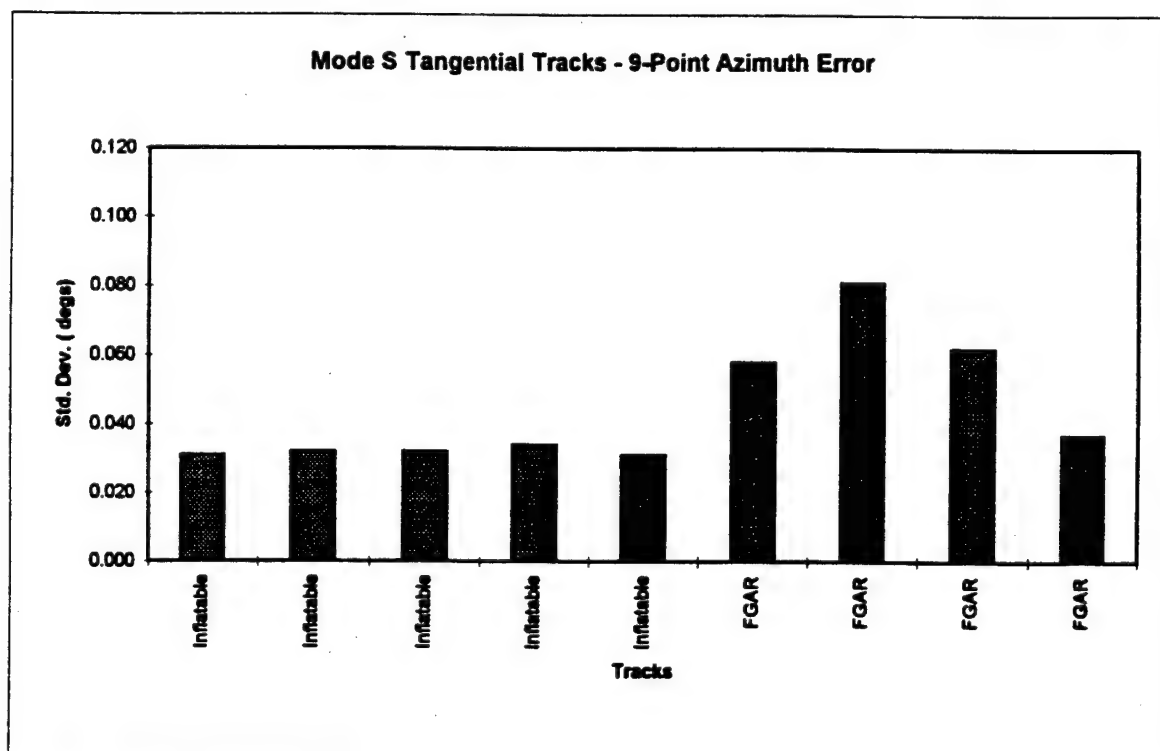


FIGURE 14

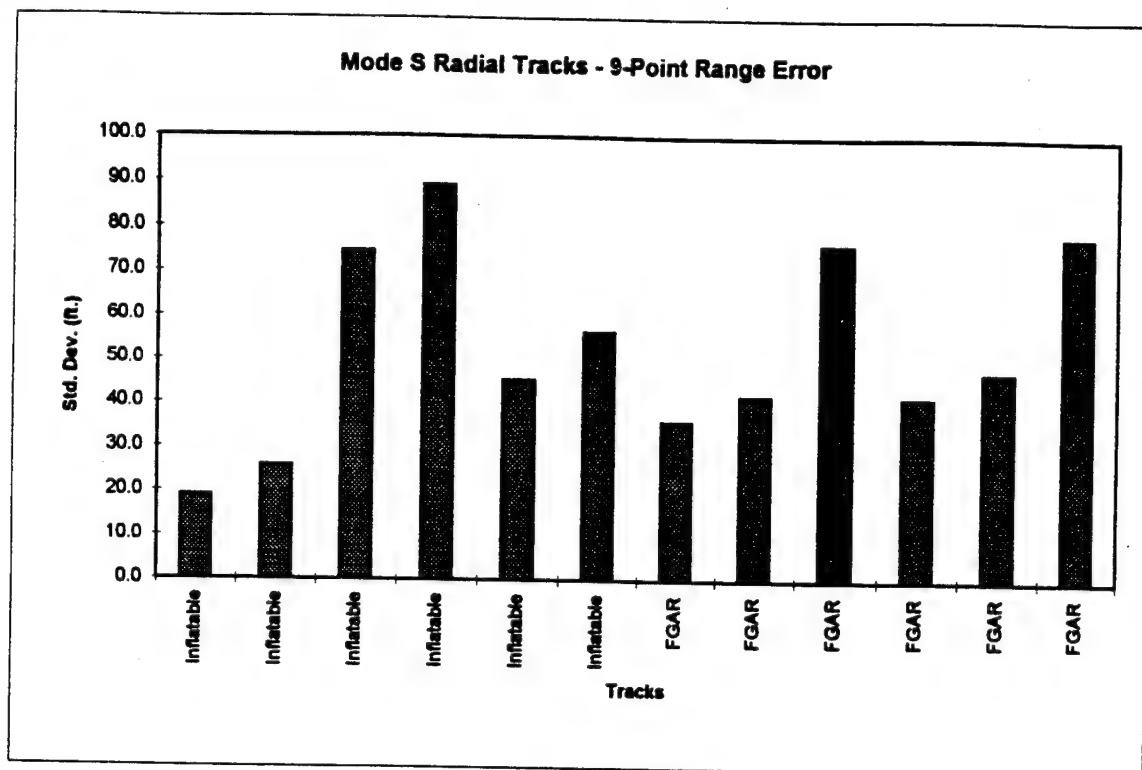


FIGURE 15

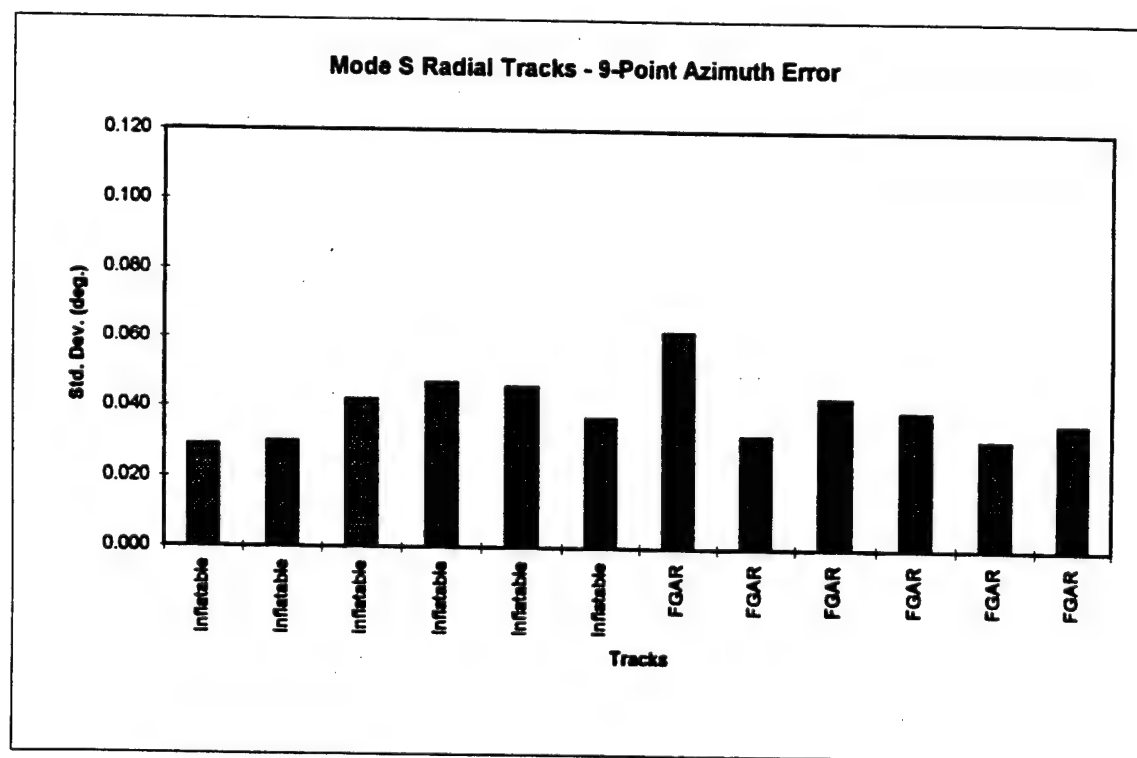


FIGURE 16

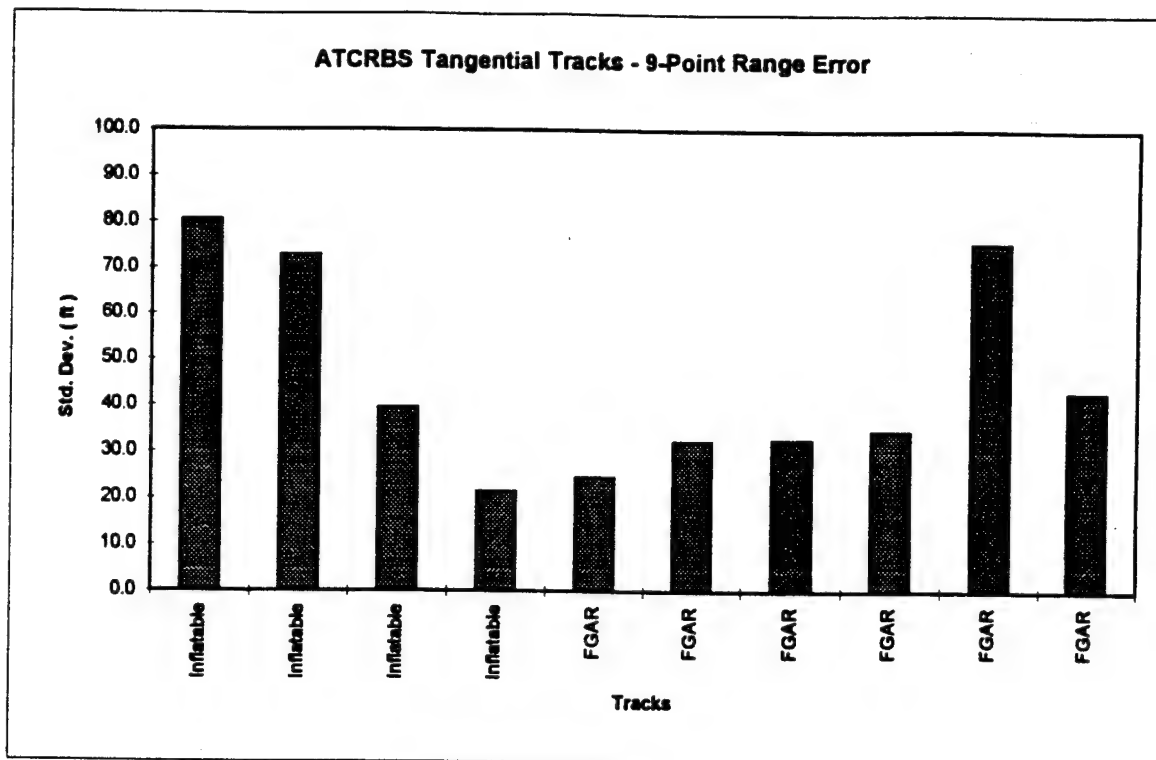


FIGURE 17

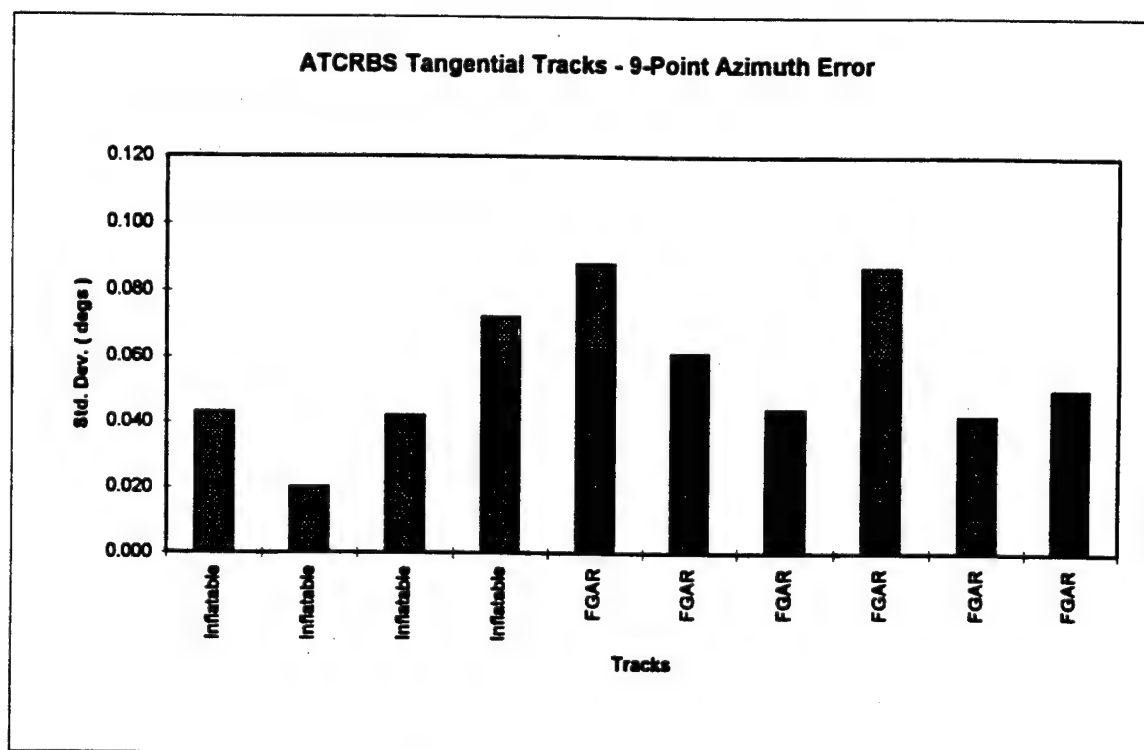


FIGURE 18

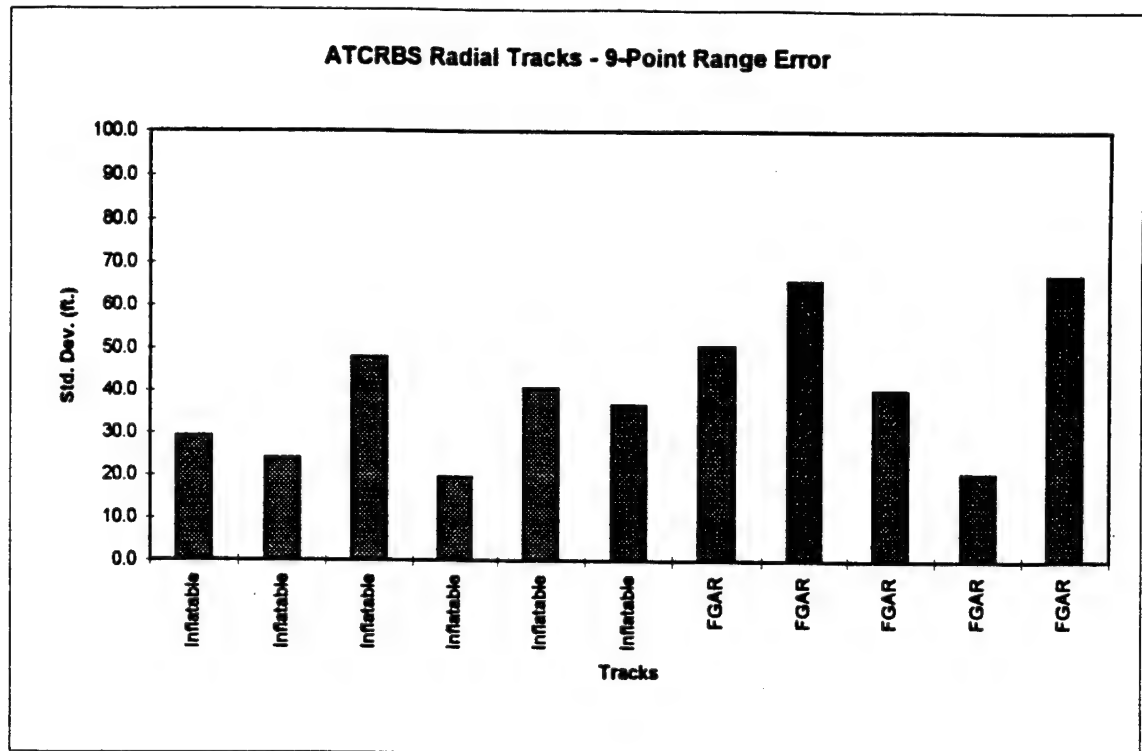


FIGURE 19

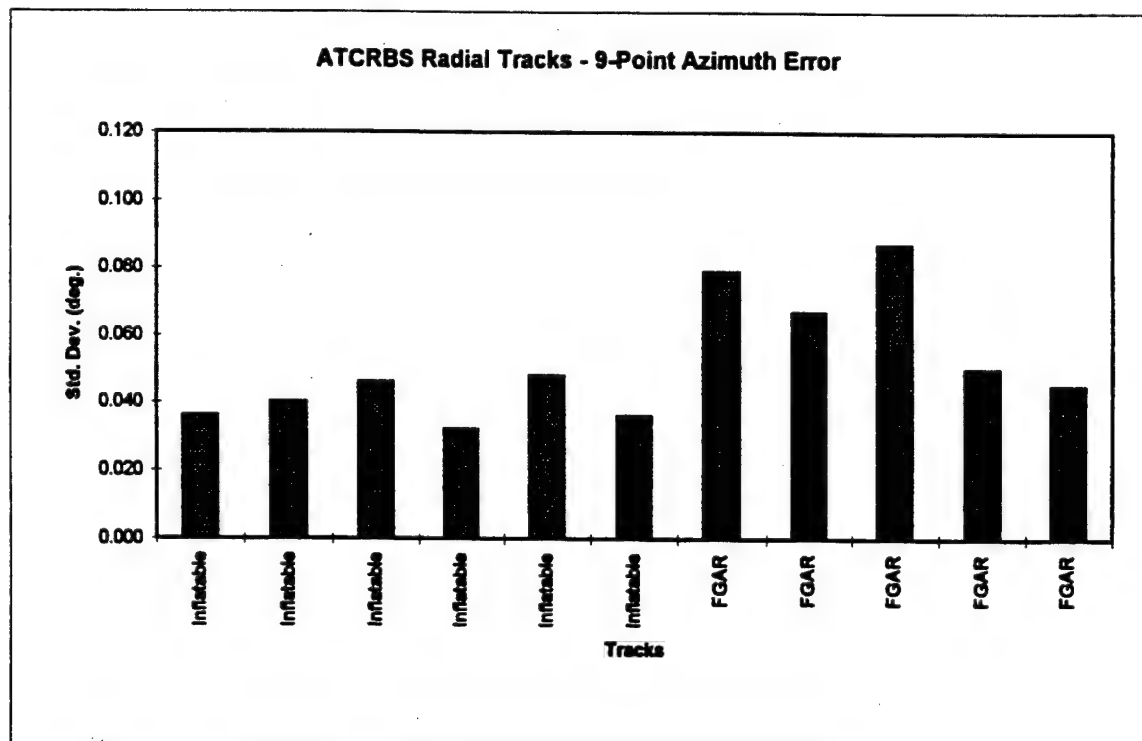
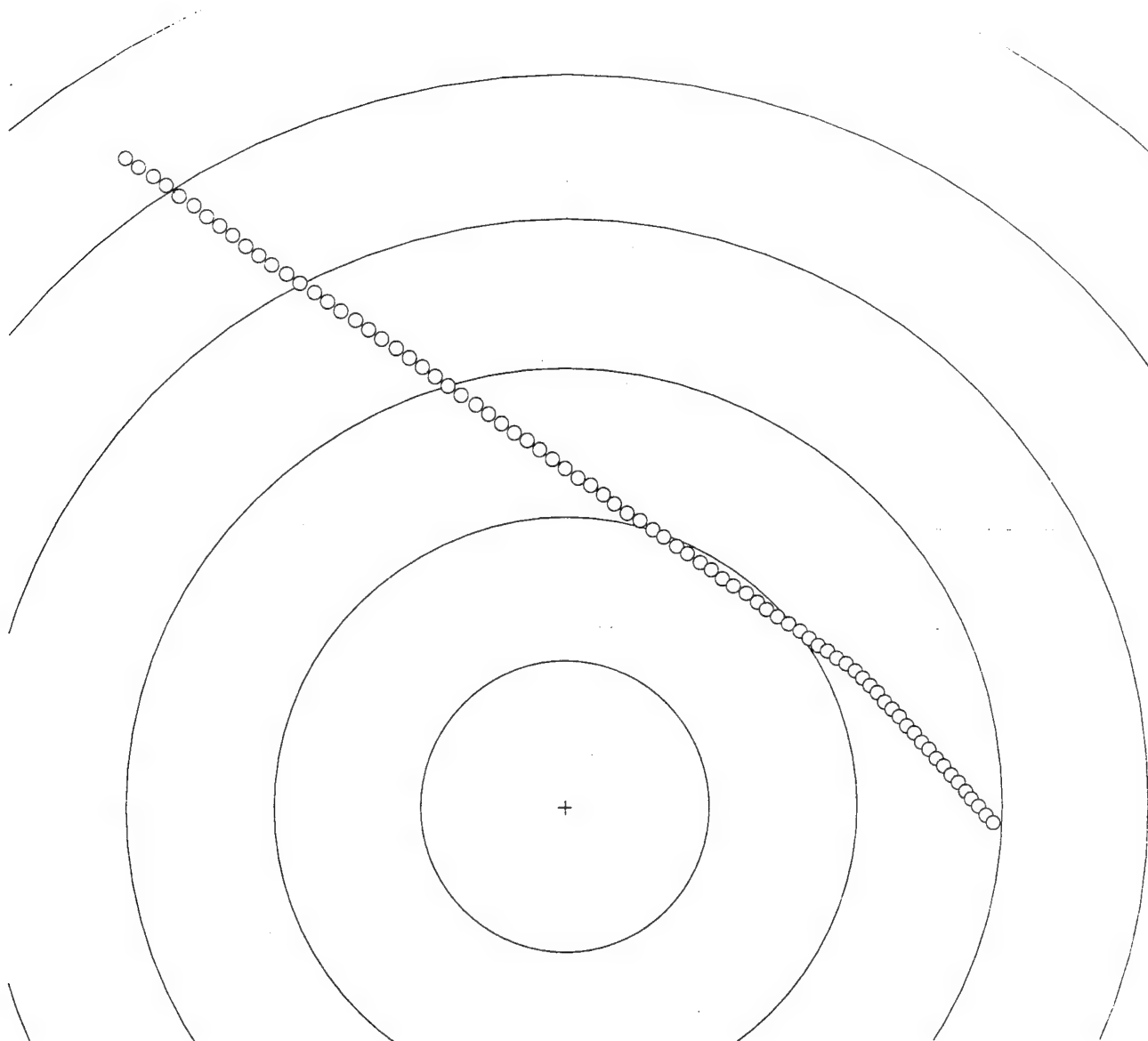


FIGURE 20



INFLATABLE

Mode S

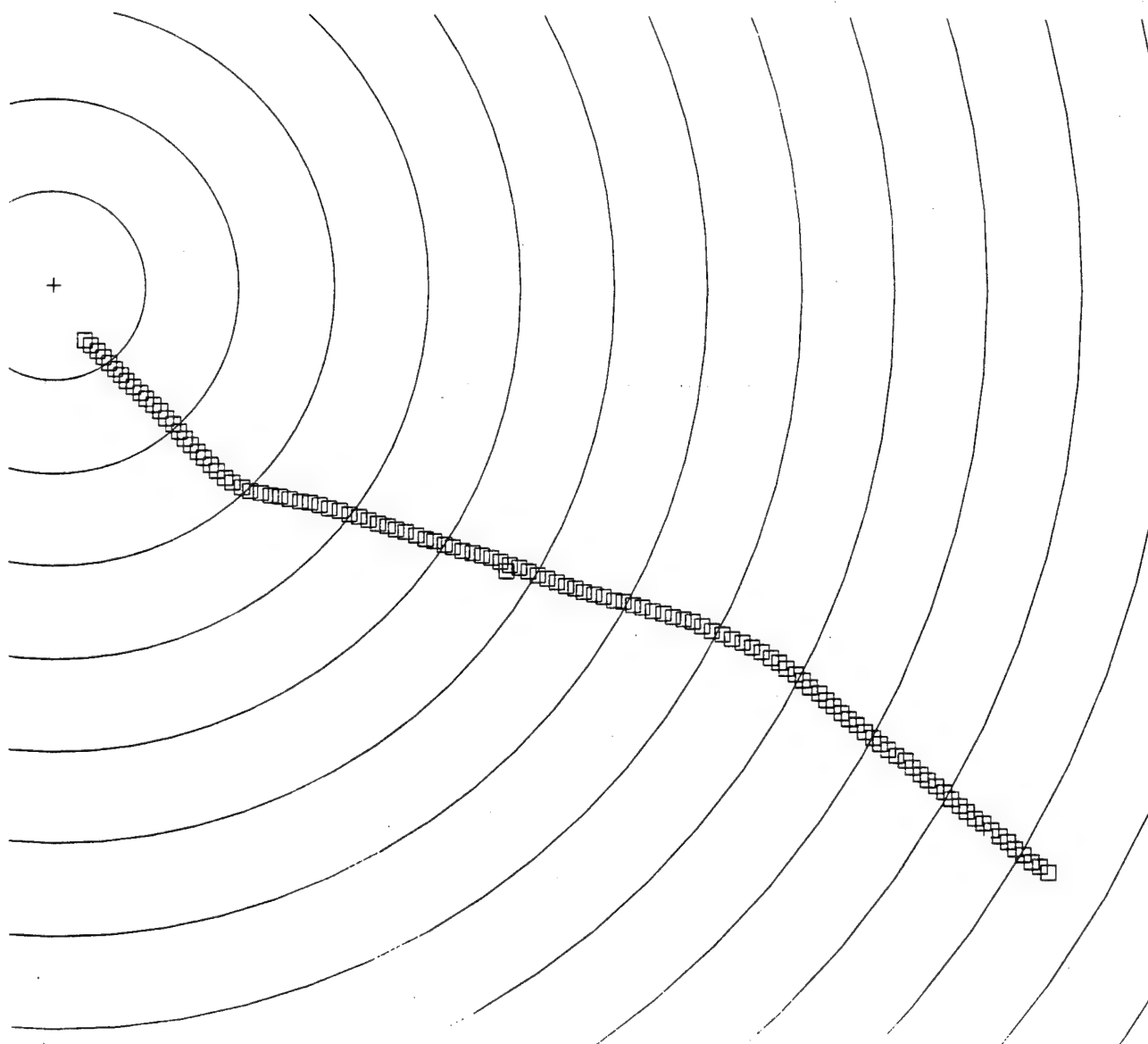
ID

3/A Code

A0BF7C

0510

FIGURE 21



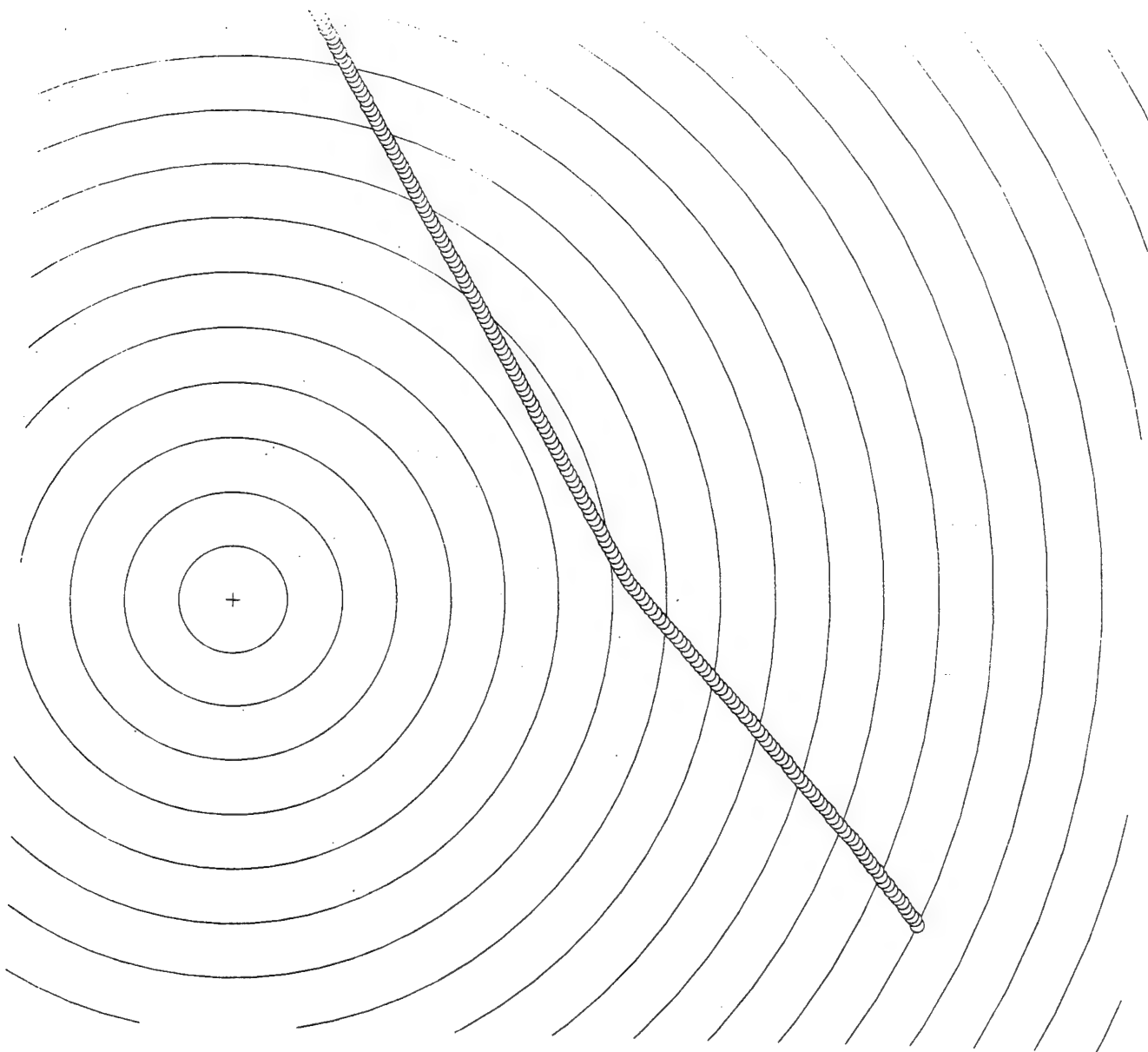
INFLATABLE

ATCRBS

3/A Code

3050

FIGURE 22

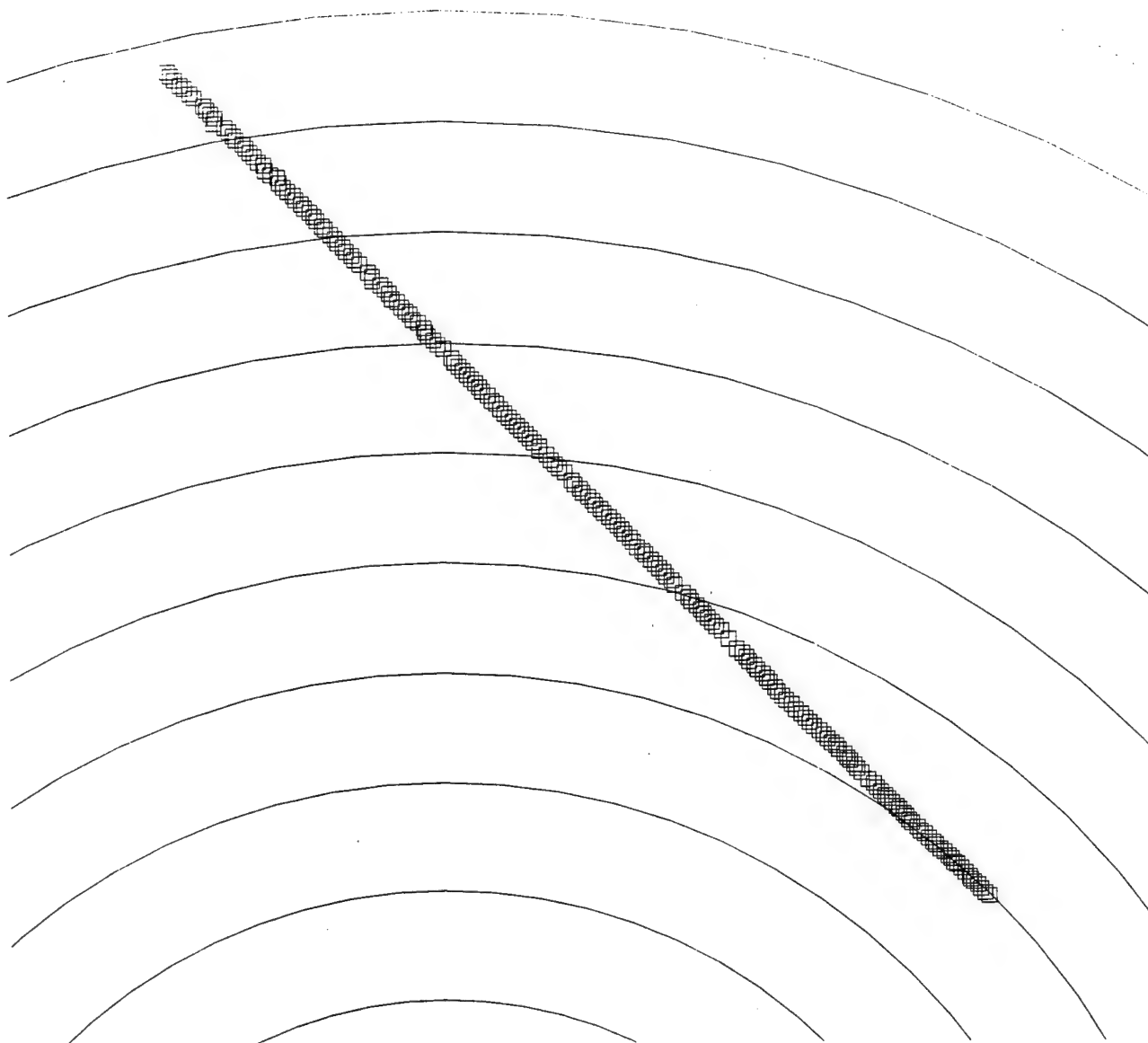


FGAR

ID
3/A Code

A00676
7367

FIGURE 23



FGAR

ATCRBS

3/A Code

5514

FIGURE 24

| | Date | Fruit Replies | | Average Fruit | | Fruit Rate | | Sample Scans |
|------------|----------|---------------|--------|---------------|--------|------------|--------|--------------|
| | | ATCRBS | Mode S | ATCRBS | Mode S | ATCRBS | Mode S | |
| Inflatable | 9/12/94 | 192000 | 10514 | 936.6 | 51.3 | 478.1 | 26.2 | 205 |
| Inflatable | 9/13/94 | 240274 | 13271 | 1044.7 | 57.7 | 532.9 | 29.4 | 230 |
| Inflatable | 9/14/94 | 207761 | 11078 | 1013.5 | 54 | 517 | 27.6 | 205 |
| Inflatable | 9/15/94 | 178279 | 8521 | 788.8 | 37.7 | 402.7 | 19.2 | 226 |
| Inflatable | 9/16/94 | 184902 | 10110 | 836.7 | 45.7 | 427.1 | 23.4 | 221 |
| Inflatable | 9/19/94 | 183807 | 16497 | 785.5 | 70.5 | 401.3 | 36 | 234 |
| Inflatable | 9/20/94 | 167080 | 9258 | 788.1 | 43.7 | 402.3 | 22.3 | 212 |
| FGAR | 10/17/94 | 232607 | 11032 | 877.8 | 41.6 | 448.5 | 21.3 | 265 |
| FGAR | 10/18/94 | 147343 | 9274 | 685.3 | 43.1 | 350.1 | 22 | 215 |
| FGAR | 10/19/94 | 241735 | 11287 | 1140.3 | 53.2 | 582.6 | 27.2 | 212 |
| FGAR | 10/20/94 | 142601 | 5242 | 672.6 | 24.7 | 343.7 | 12.6 | 212 |
| FGAR | 10/21/94 | 171369 | 9044 | 844.2 | 44.6 | 431.3 | 22.8 | 203 |
| FGAR, Wet | 12/6/94 | 168982 | 6894 | 824.3 | 33.6 | 421.2 | 17.2 | 205 |

TABLE 11

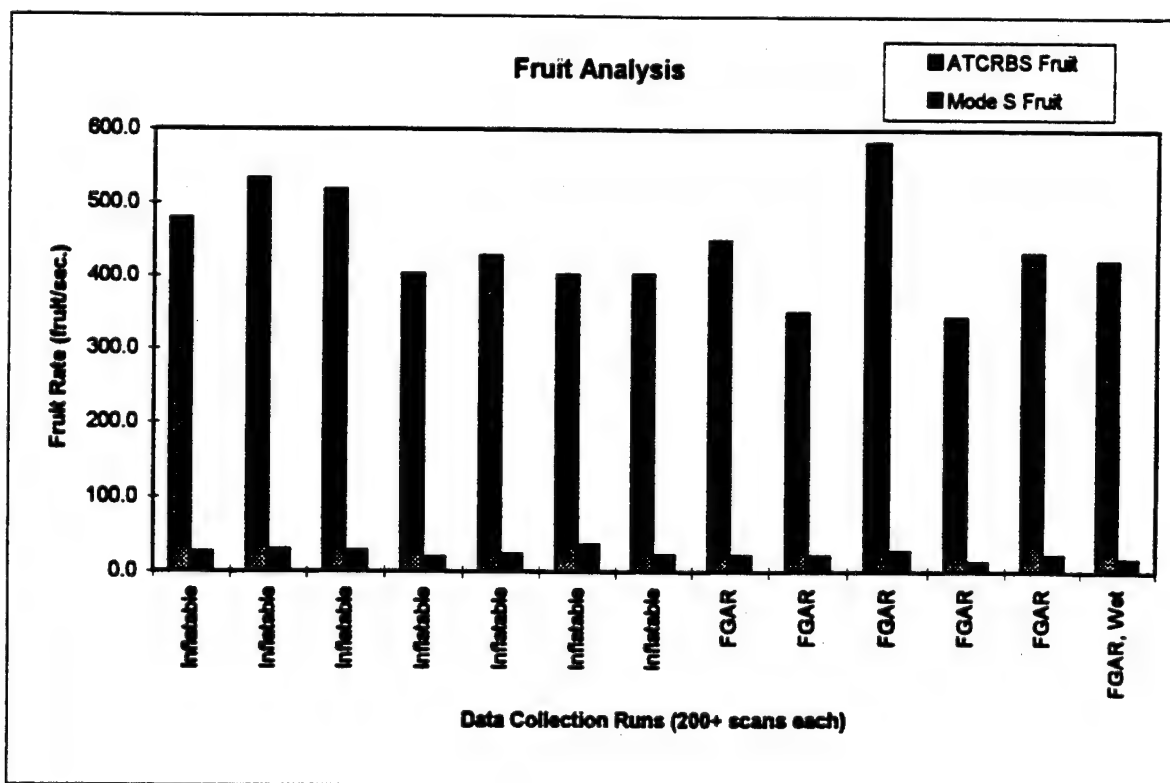
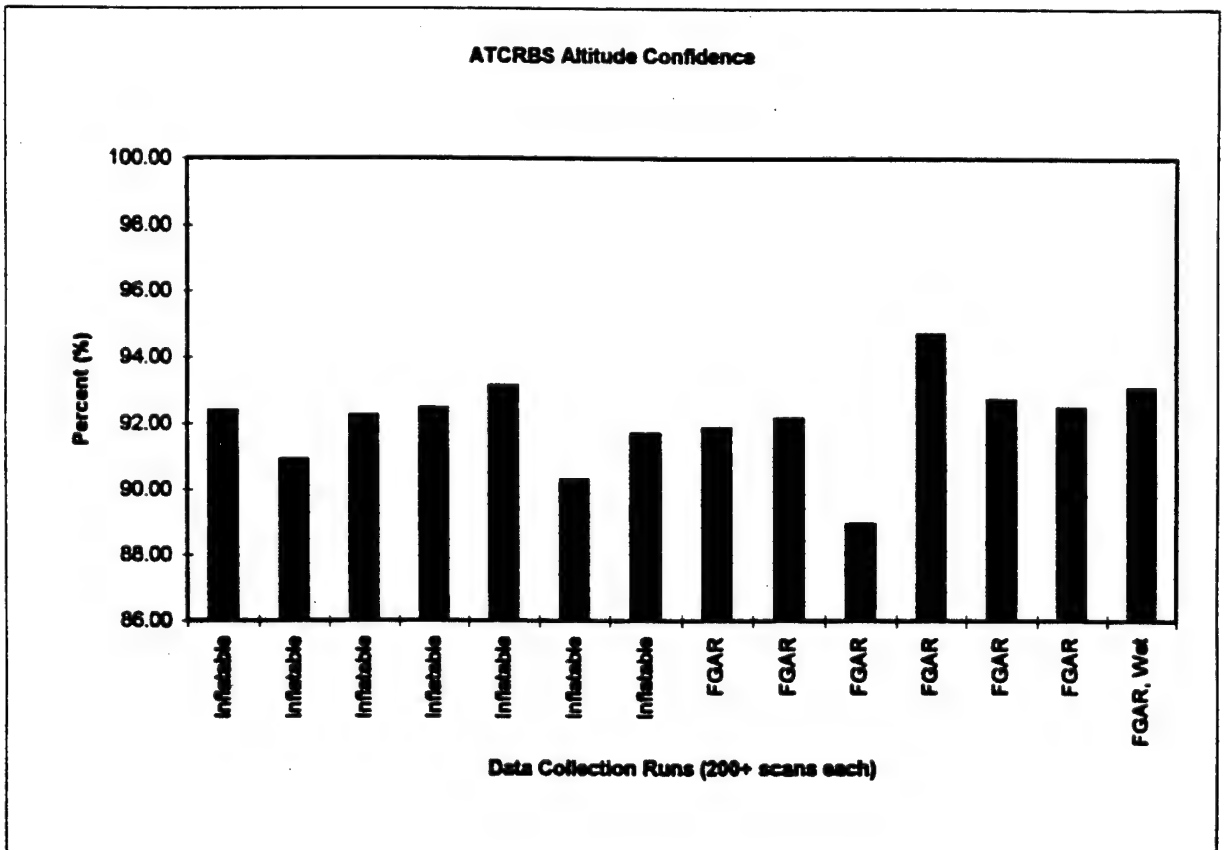
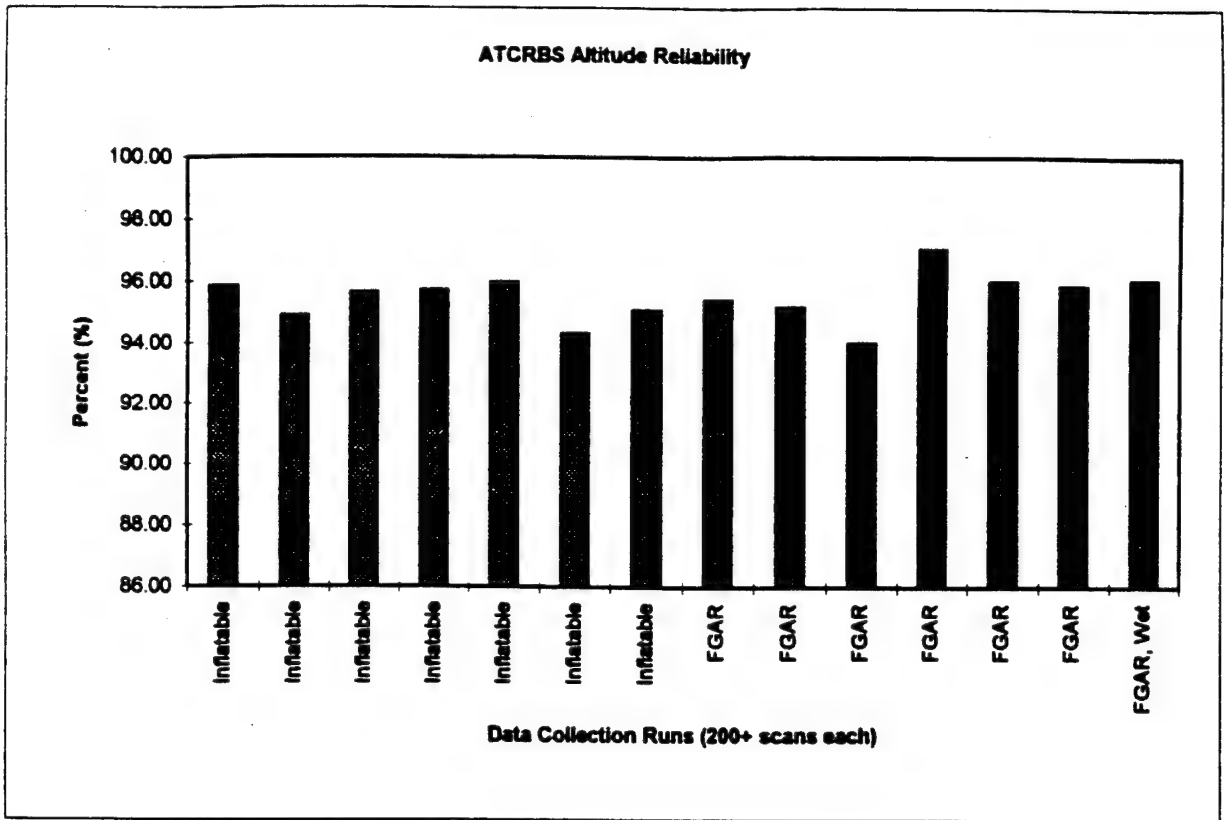
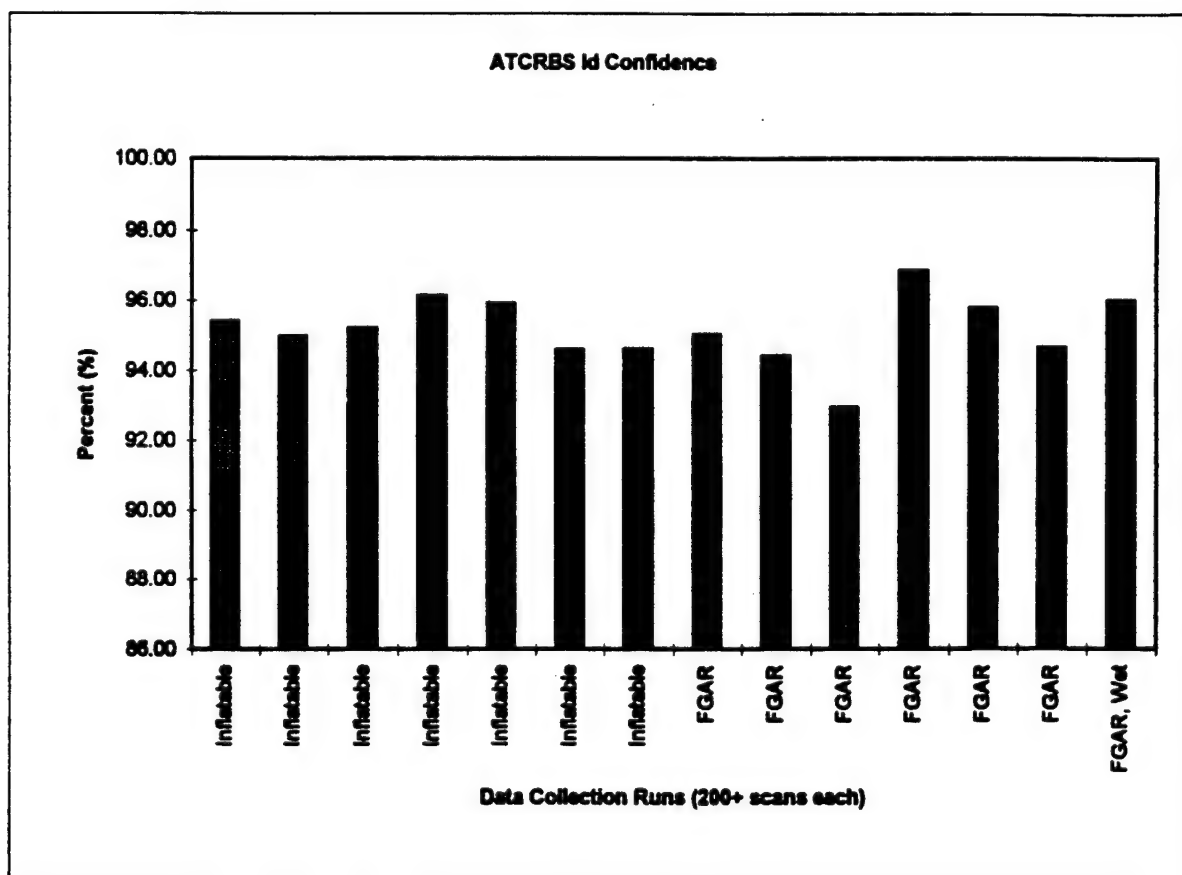
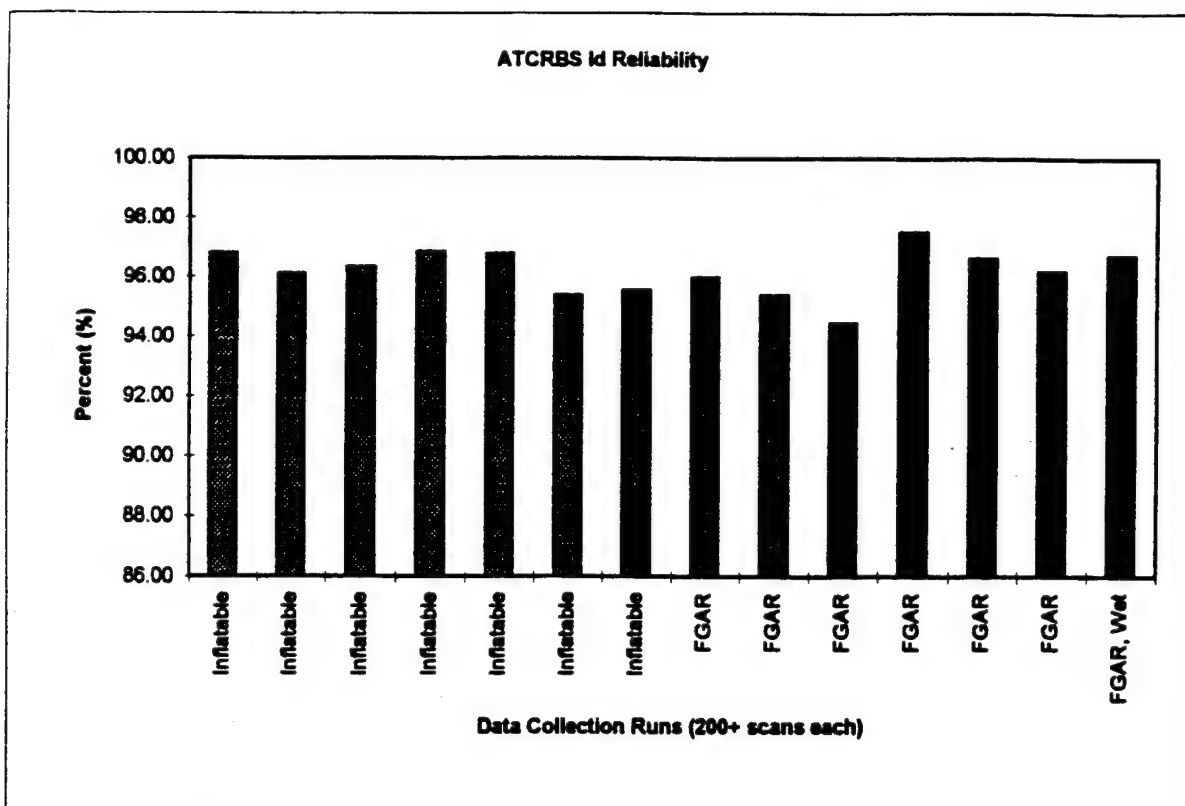


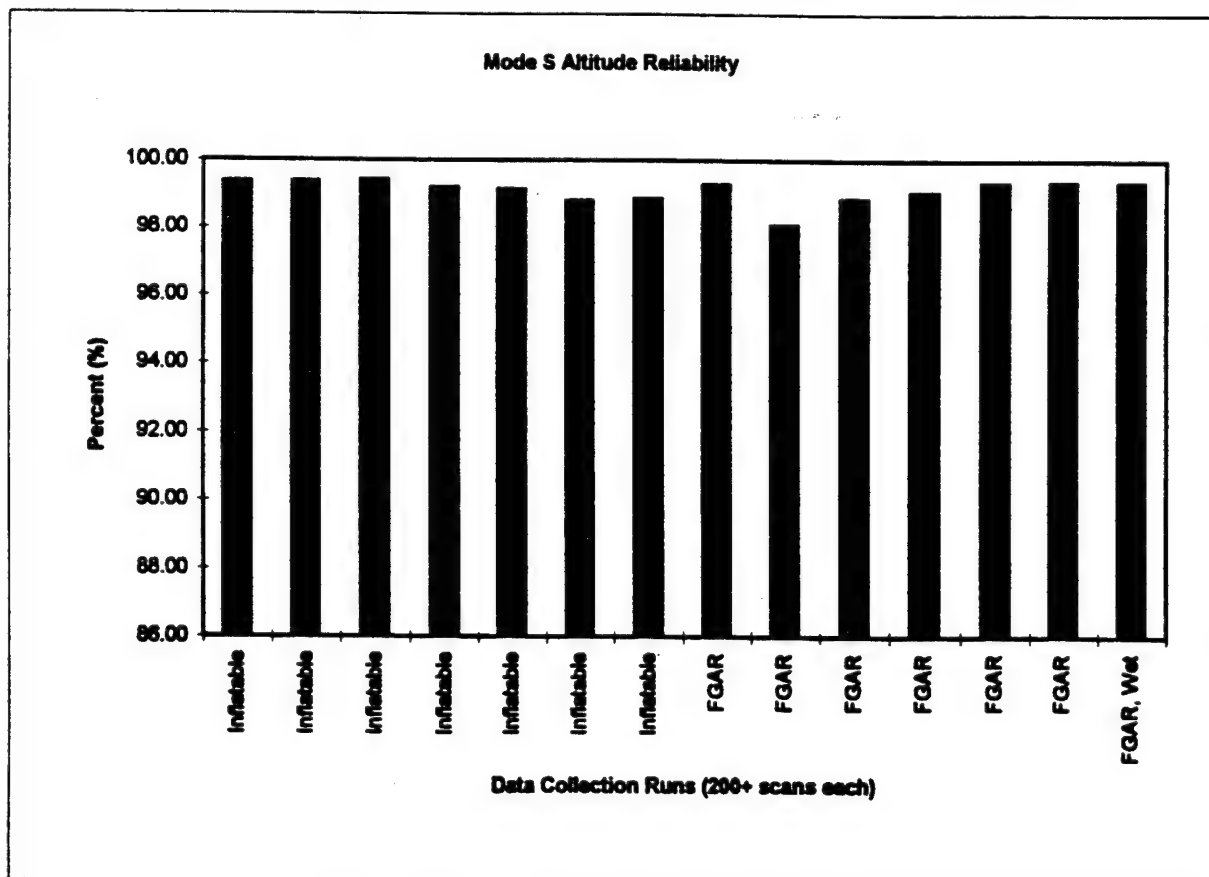
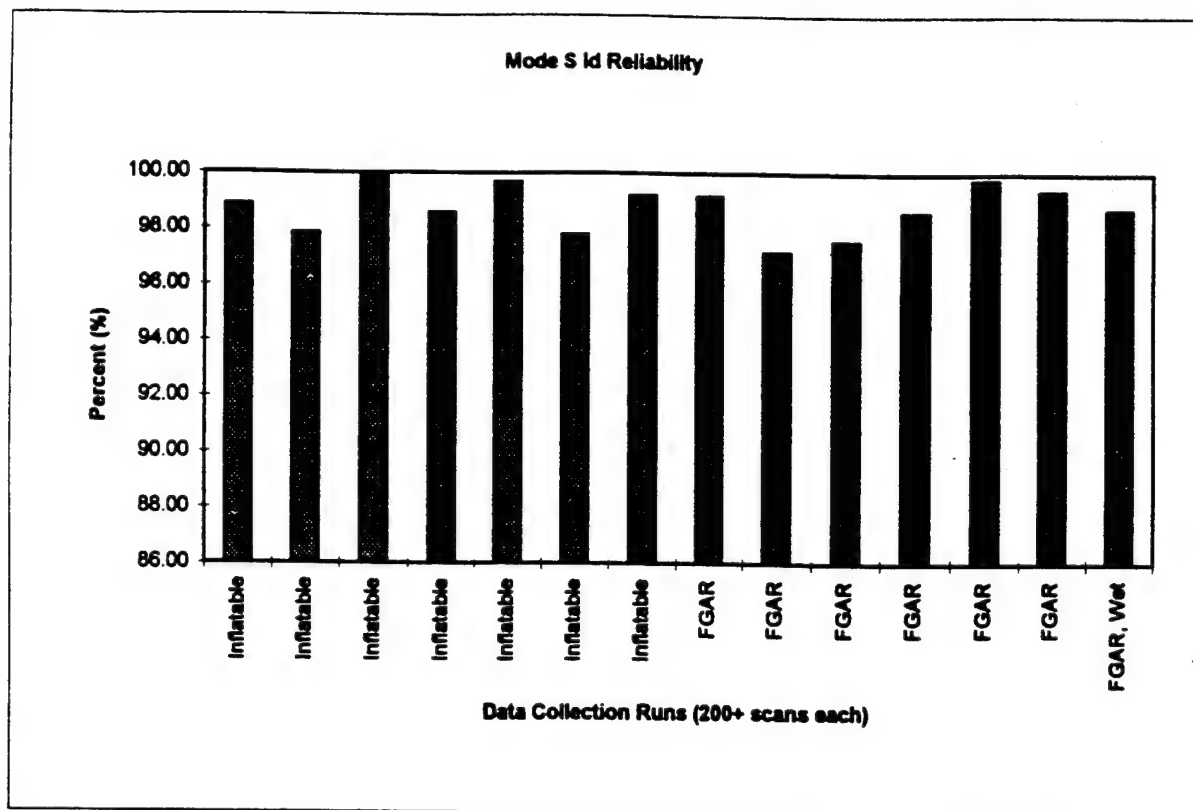
FIGURE 34



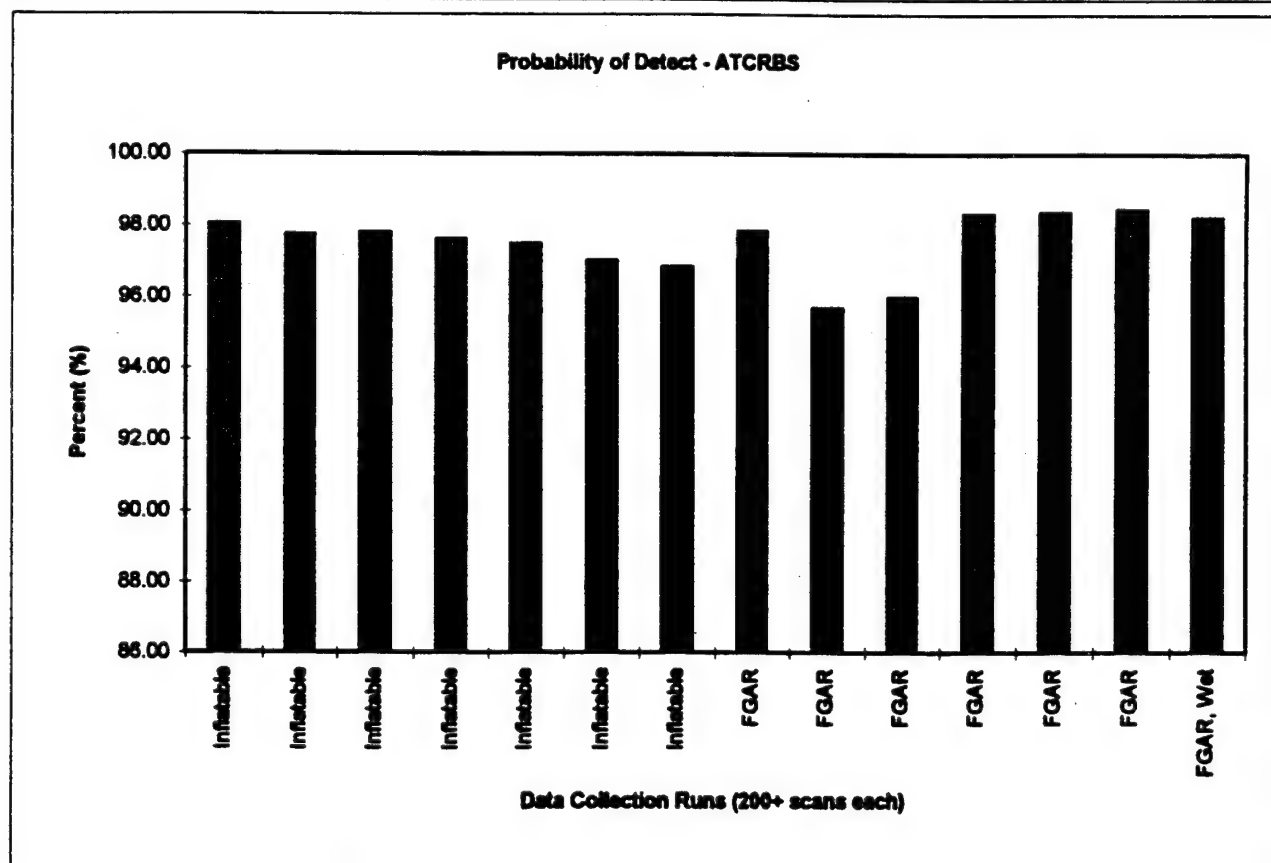
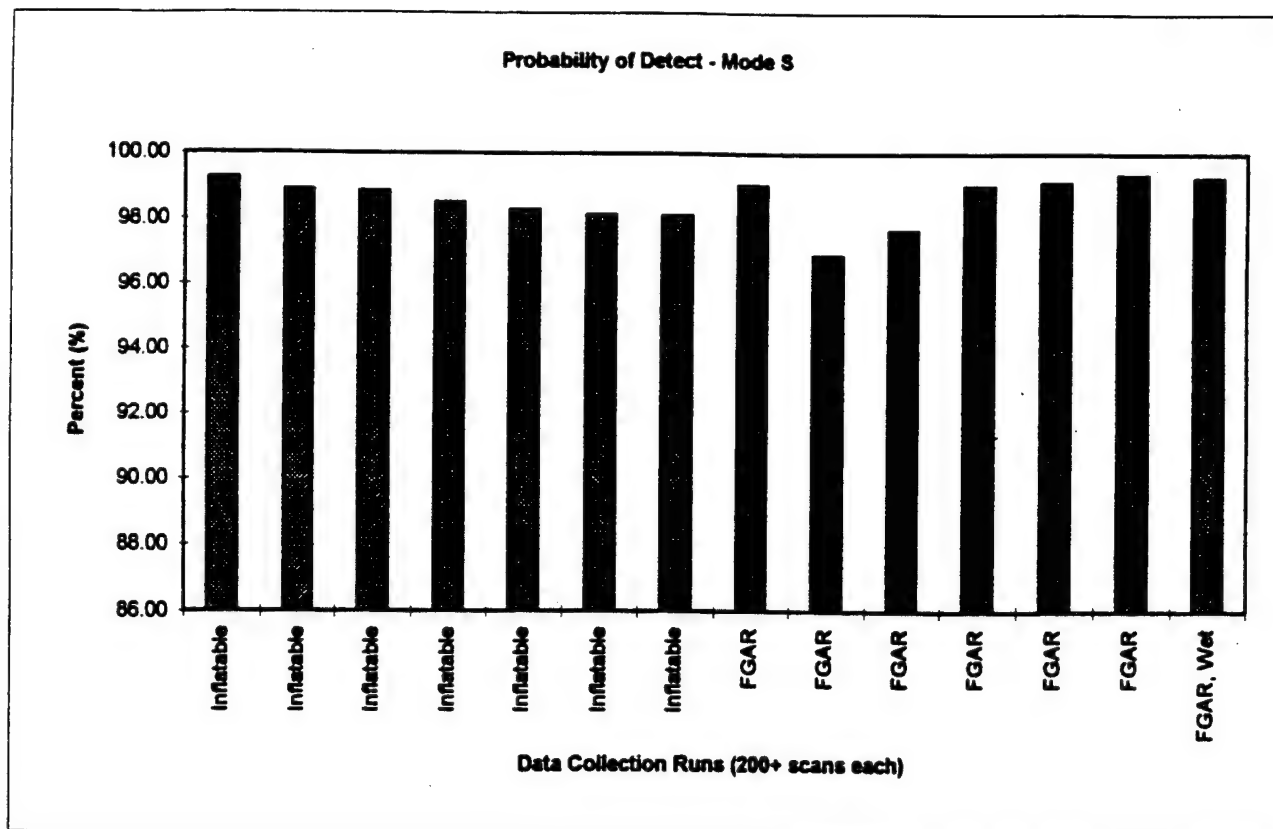
FIGURES 32 & 33



FIGURES 30 & 31



FIGURES 28 & 29



FIGURES 26 & 27

| | | Total | | | | | |
|------------|----------|------------|-----------|---------|----------|-----------|------------|
| | | Track Life | Beacon Pd | Id Rel. | Id Conf. | Alt. Rel. | Alt. Conf. |
| Inflatable | 9/12/94 | 116915 | 98.51 | 97.60 | 95.41 | 97.26 | 92.39 |
| Inflatable | 9/13/94 | 124862 | 98.16 | 96.76 | 94.97 | 96.59 | 90.89 |
| Inflatable | 9/14/94 | 115379 | 98.19 | 97.72 | 95.21 | 97.12 | 92.23 |
| Inflatable | 9/15/94 | 93258 | 97.96 | 97.53 | 96.13 | 97.13 | 92.46 |
| Inflatable | 9/16/94 | 100996 | 97.81 | 97.97 | 95.92 | 97.30 | 93.14 |
| Inflatable | 9/19/94 | 109406 | 97.49 | 96.38 | 94.59 | 96.19 | 90.29 |
| Inflatable | 9/20/94 | 102938 | 97.31 | 96.92 | 94.62 | 96.51 | 91.69 |
| FGAR | 10/17/94 | 138452 | 98.32 | 97.26 | 95.03 | 96.98 | 91.86 |
| FGAR | 10/18/94 | 100433 | 96.18 | 96.10 | 94.41 | 96.37 | 92.15 |
| FGAR | 10/19/94 | 103328 | 96.63 | 95.64 | 92.94 | 95.90 | 88.94 |
| FGAR | 10/20/94 | 79080 | 98.58 | 97.92 | 96.85 | 97.82 | 94.69 |
| FGAR | 10/21/94 | 103895 | 98.69 | 97.98 | 95.79 | 97.43 | 92.72 |
| FGAR | 10/27/94 | 115099 | 98.78 | 97.38 | 94.67 | 97.18 | 92.48 |
| FGAR Wet | 12/6/94 | 103169 | 98.63 | 97.45 | 96.00 | 97.31 | 93.07 |

| | | Mode S | | | | | |
|------------|----------|------------|-----------|---------|----------|-----------|------------|
| | | Track Life | Beacon Pd | Id Rel. | Id Conf. | Alt. Rel. | Alt. Conf. |
| Inflatable | 9/12/94 | 45850 | 99.26 | 98.86 | n/a | 99.37 | n/a |
| Inflatable | 9/13/94 | 46761 | 98.87 | 97.84 | n/a | 99.36 | n/a |
| Inflatable | 9/14/94 | 44502 | 98.84 | 99.92 | n/a | 99.42 | n/a |
| Inflatable | 9/15/94 | 37524 | 98.48 | 98.56 | n/a | 99.20 | n/a |
| Inflatable | 9/16/94 | 41660 | 98.27 | 99.68 | n/a | 99.15 | n/a |
| Inflatable | 9/19/94 | 45094 | 98.14 | 97.78 | n/a | 98.80 | n/a |
| Inflatable | 9/20/94 | 38316 | 98.12 | 99.19 | n/a | 98.86 | n/a |
| FGAR | 10/17/94 | 54955 | 99.03 | 99.18 | n/a | 99.29 | n/a |
| FGAR | 10/18/94 | 40494 | 96.90 | 97.16 | n/a | 98.08 | n/a |
| FGAR | 10/19/94 | 39605 | 97.66 | 97.55 | n/a | 98.87 | n/a |
| FGAR | 10/20/94 | 30504 | 99.01 | 98.60 | n/a | 99.06 | n/a |
| FGAR | 10/21/94 | 44045 | 99.11 | 99.79 | n/a | 99.34 | n/a |
| FGAR | 10/27/94 | 42953 | 99.35 | 99.38 | n/a | 99.36 | n/a |
| FGAR Wet | 12/6/94 | 38789 | 99.28 | 98.71 | n/a | 99.36 | n/a |

| | | ATCRBS | | | | | |
|------------|----------|------------|-----------|---------|----------|-----------|------------|
| | | Track Life | Beacon Pd | Id Rel. | Id Conf. | Alt. Rel. | Alt. Conf. |
| Inflatable | 9/12/94 | 71065 | 98.03 | 96.79 | 95.41 | 95.87 | 92.39 |
| Inflatable | 9/13/94 | 78101 | 97.74 | 96.11 | 94.97 | 94.91 | 90.89 |
| Inflatable | 9/14/94 | 70877 | 97.78 | 96.33 | 95.21 | 95.65 | 92.23 |
| Inflatable | 9/15/94 | 55734 | 97.61 | 96.83 | 96.13 | 95.72 | 92.46 |
| Inflatable | 9/16/94 | 59336 | 97.49 | 96.76 | 95.92 | 95.99 | 93.14 |
| Inflatable | 9/19/94 | 64312 | 97.03 | 95.38 | 94.59 | 94.33 | 90.29 |
| Inflatable | 9/20/94 | 64622 | 96.84 | 95.55 | 94.62 | 95.09 | 91.69 |
| FGAR | 10/17/94 | 83497 | 97.85 | 95.99 | 95.03 | 95.43 | 91.86 |
| FGAR | 10/18/94 | 59939 | 95.69 | 95.38 | 94.41 | 95.19 | 92.15 |
| FGAR | 10/19/94 | 63723 | 95.98 | 94.43 | 92.94 | 94.02 | 88.94 |
| FGAR | 10/20/94 | 48576 | 98.32 | 97.50 | 96.85 | 97.04 | 94.69 |
| FGAR | 10/21/94 | 59850 | 98.38 | 96.64 | 95.79 | 96.01 | 92.72 |
| FGAR | 10/27/94 | 72146 | 98.44 | 96.18 | 94.67 | 95.86 | 92.48 |
| FGAR Wet | 12/6/94 | 64380 | 98.24 | 96.69 | 96.00 | 96.05 | 93.07 |

TABLES 8/9/10

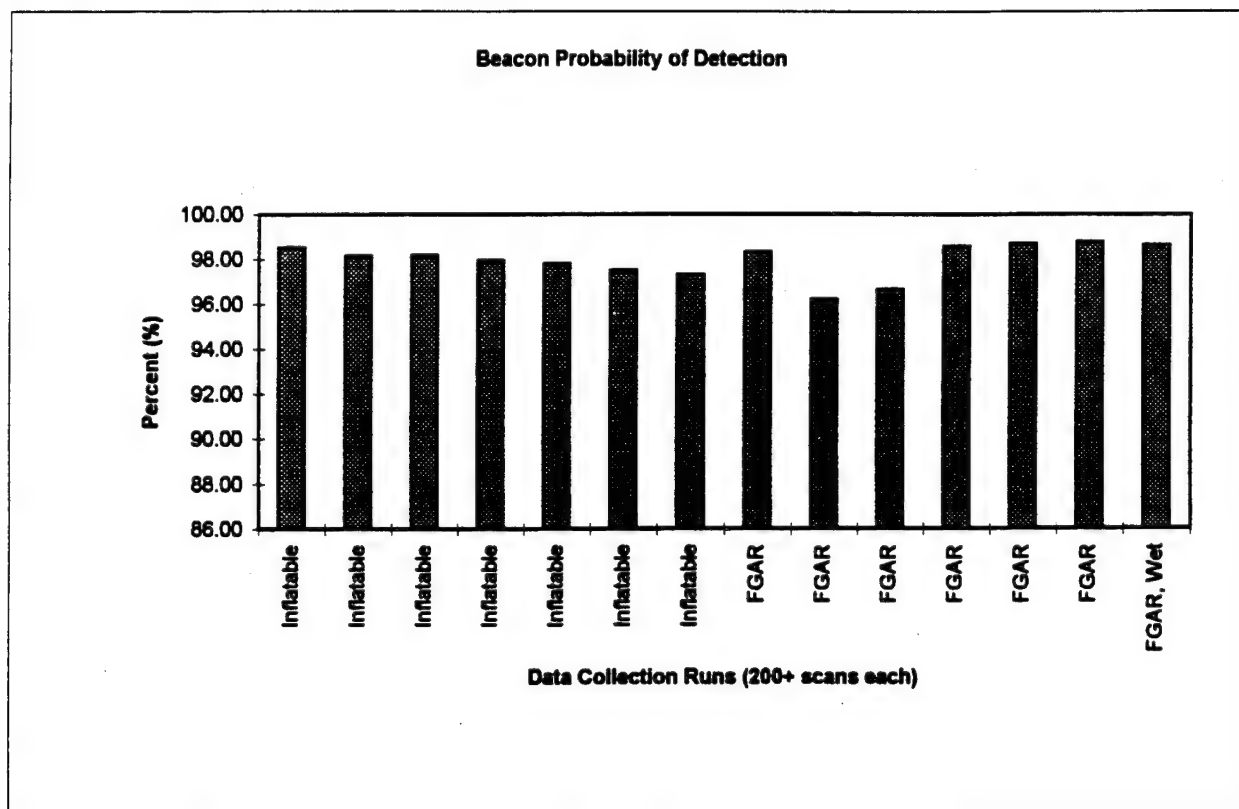


FIGURE 25

APPENDIX G

REPORT

ELECTROMAGNETIC PERFORMANCE TESTING WITH RFIM VAN
TRINIDAD EN ROUTE RADAR FACILITY (TAD)



U.S. Department
of Transportation

Memorandum

Federal Aviation Administration

Subject: INFORMATION: Radome Replacement
Tests, Trinidad, Colorado

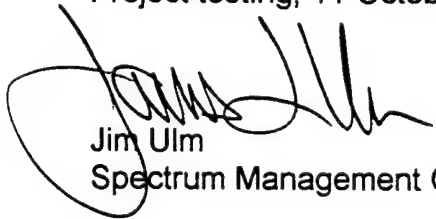
Date: 11/17/94

From: James L. Ulm, ANM-464I

Reply to Ulm
Attn of: X2324

To: Manager, ANM-464, Technical Support Section

The attached trip report applies to the Trinidad, Colorado Radome Replacement Project testing, 11 October thru 4 November 1994.


Jim Ulm
Spectrum Management Officer

TRIP REPORT

Date: 10/11/94 thru 11/4/1994

Traveler: Jim Ulm, ANM-464I, Harry Gardner, ANM-464J

Destination: Trinidad, Colorado

Purpose: ARSR Radome Replacement Project Radiated Signal Effects Testing

Background: The ARSR radome replacement, formally known as the fixed ground antenna radome (FGAR), program manager office requested ANM spectrum management office assistance in testing. The objectives of the testing are to verify that the FGAR does not degrade the electromagnetic performance of the enroute radar, Mode-S, or the Air Traffic Control Radar Beacon System (ATCRBS) antenna(s). The ANM-464 spectrum engineers operating the radio frequency interference monitoring (RFIM) van would record the primary and ATCRBS/Mode-S data, using the specialized equipment and programs available in the RFIM van. The data would be reduced and analyzed, and a report generated together with printouts, and raw data sent to the test director.

The difference between the following antenna pattern electromagnetic parameters, when measured before work begins, without a radome and with the FGAR installed, are within the specified limits:

- a. Main beam width change ($\pm 0.05^\circ$ max)
- b. Boresight error change (0.0085° RMS and $.0255^\circ$ max, vertical and horizontal)
- c. Sidelobe level error change (± 1 dB, using a sidelobe that is -25 dB from the main lobe of reference)

Activity: On October 11, 1994 Harry Gardner, ANM-464J and I traveled to Trinidad Colorado ARSR and to begin the FGAR testing. Horizontal antenna patterns were taken at the following locations around the ARSR site:

| | | |
|------------------|------------------|-----------------|
| Test Location #1 | 373329N 1040157W | 306.58° 1.08 nm |
| Test Location #2 | 373331N 1035918W | 60.02° 1.41 nm |
| Test Location #3 | 373155N 1040033W | 165.39° .95 nm |

Three sets of 360° data were taken for the primary radar, the ATCRB (SLS on), and ATCRB (SLS off) and 3° of main beam data were taken at each location (attachment 1).

We returned on October 25 when the old radome had been removed and took the same measurements as above, with the exception of ATCRB (SLS off) (no omni antenna in place), in addition performed morning and evening vertical antenna measurements (attachment 2).

We returned again on October 31 after the new radome was installed and completed horizontal and vertical antenna measurements (attachment 3).

Conclusions: The following is a list of findings:

1. Main Beam Width Change

| | Loc #1 | Loc #2 | Loc #3 | Average |
|------------|--------|--------|--------|---------|
| Original | 1.60 | 1.58 | 1.56 | 1.58 |
| *No Radome | 1.62 | 1.56 | 1.51 | 1.56 |
| New Radome | 1.54 | 1.55 | 1.56 | 1.55 |
| Δ Old/New | 0.06 | 0.03 | N/C | 0.03 |

The overall difference in 3 dB beam width is 0.03 degrees.

2. Boresight Change

| | Loc #1 | Loc #2 | Loc #3 |
|------------|---------|--------|---------|
| Original | 294.755 | 53.633 | 155.941 |
| *No Radome | 295.657 | 53.633 | 156.392 |
| New Radome | 294.755 | 53.633 | 155.941 |
| Δ Old/New | N/C | N/C | N/C |

There was virtually no change in boresite between the old radome and the new radome in the horizontal plane. Two vertical measurements were made without the radome. Four vertical measurements were made with the new radome in place.

*NOTE: The "No Radome" readings are not considered in the calculations due to wind loading on the antenna sail. The rotation rate varied somewhat with wind speed during the testing with the radome off.

3. Sidelobe Level Change

Due to the rotary joint replacement between the initial measurements with the original radome and measurements with the new radome, the data is invalid. A typical difference between no radome and the new radome sidelobe is included (attachment 4).

| | | |
|---------------------------|----------------------|----------------|
| Contacts: Harold Sedgwick | Raytheon Service Co. | (609) 641-5544 |
| Len Baker | ACW-100 | (609) 485-5353 |
| Steve Lucero | TAD ARSR | (719) 846-9628 |

Attachments (4)

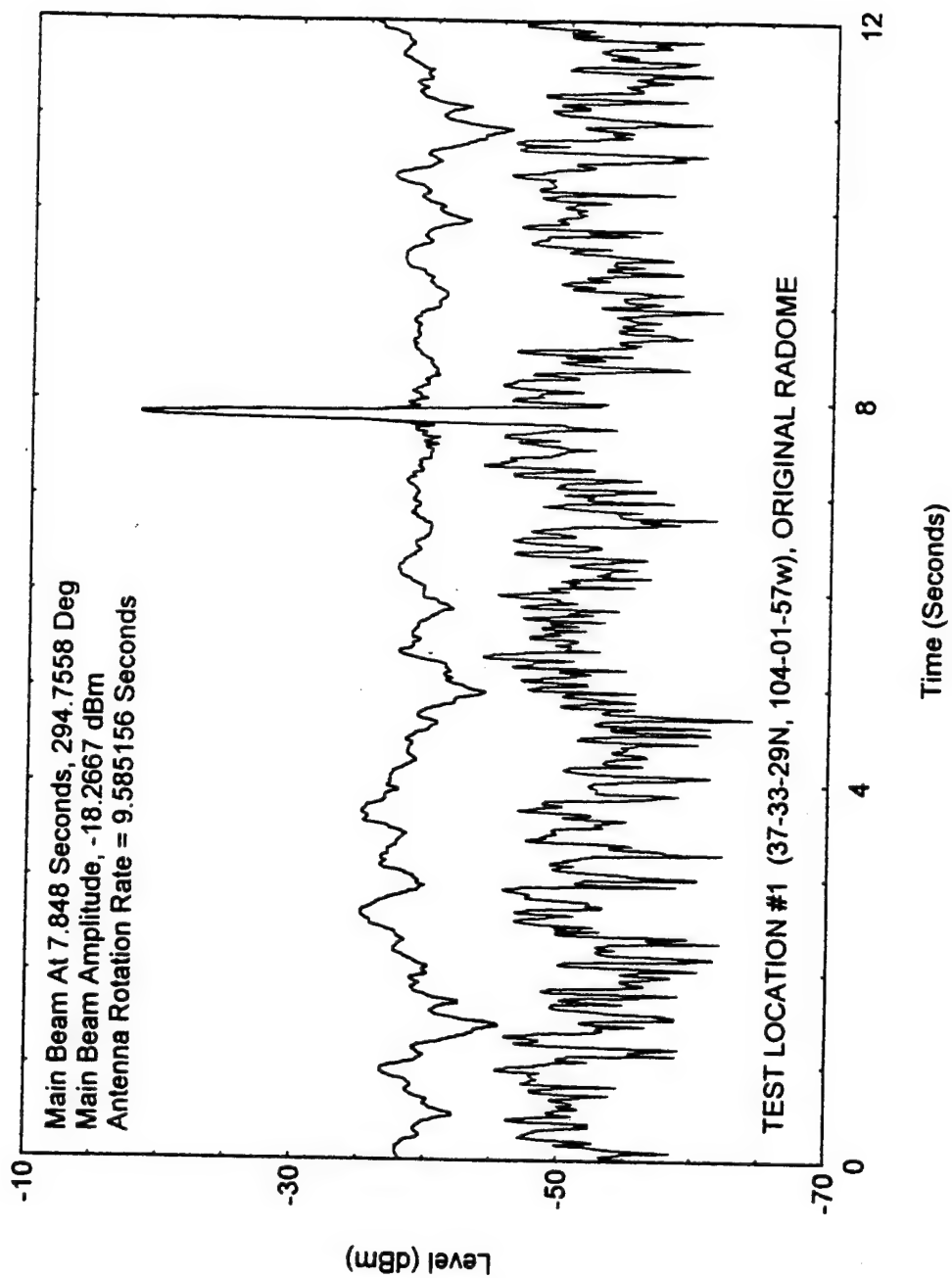
cc: ANM-462
TAD ARSR
ACW-100

ATTACHMENT 1

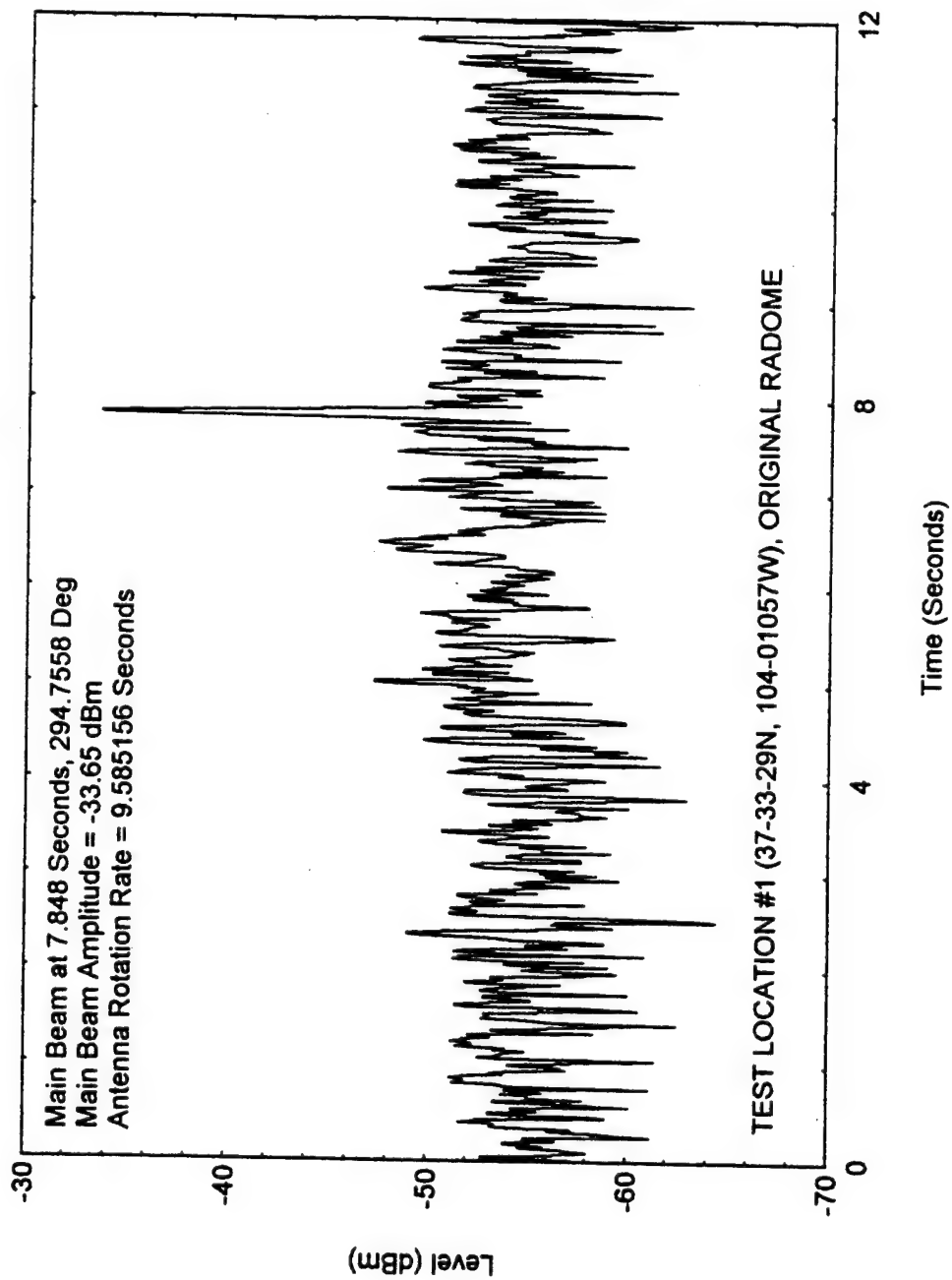
ORIGINAL RADOME

360° Horizontal Plots
Beam Width Plots

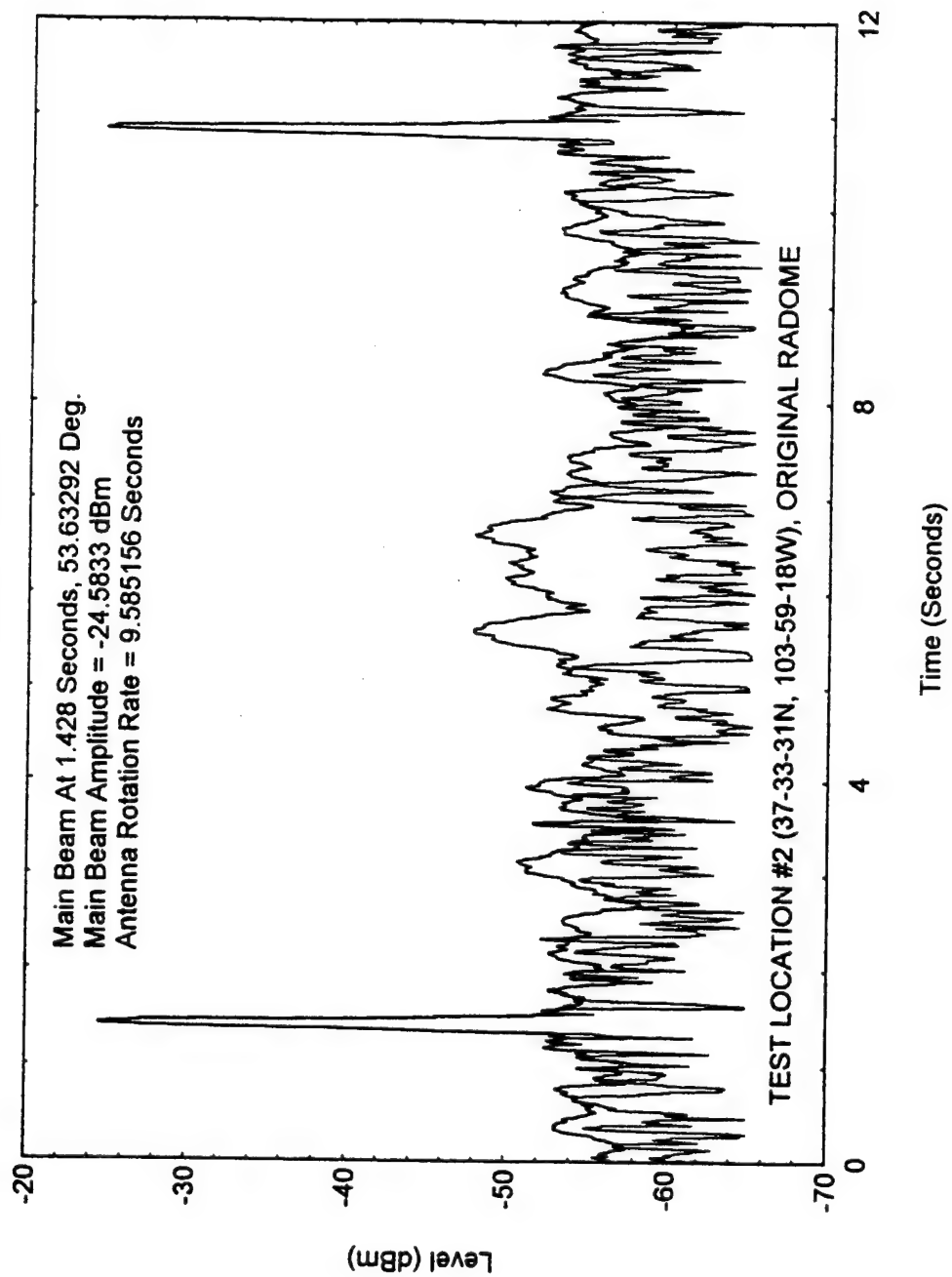
TRINIDAD, CO HORIZONTAL BEACON PLOT



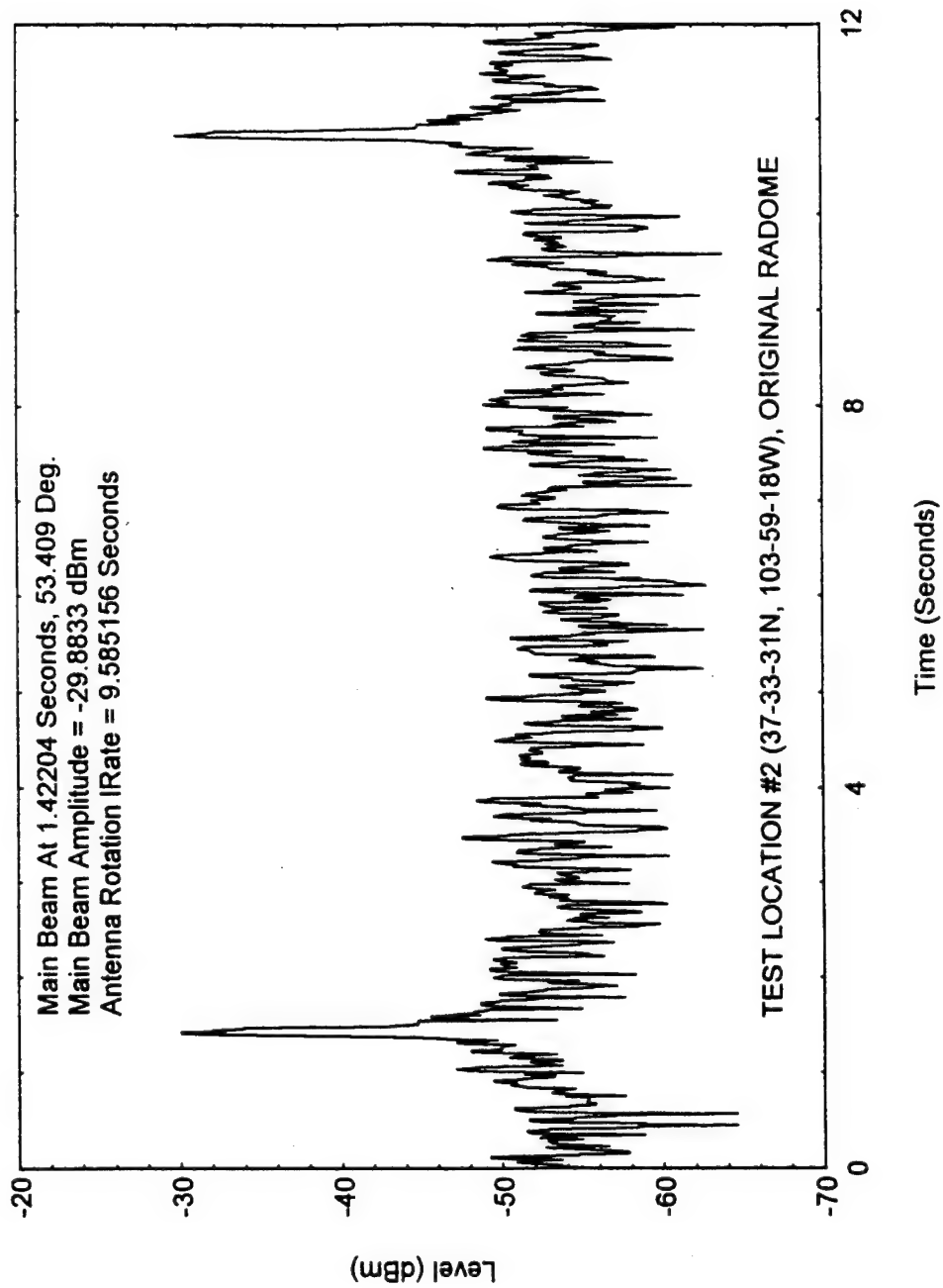
TRINIDAD, CO HORIZONTAL RADAR PLOT



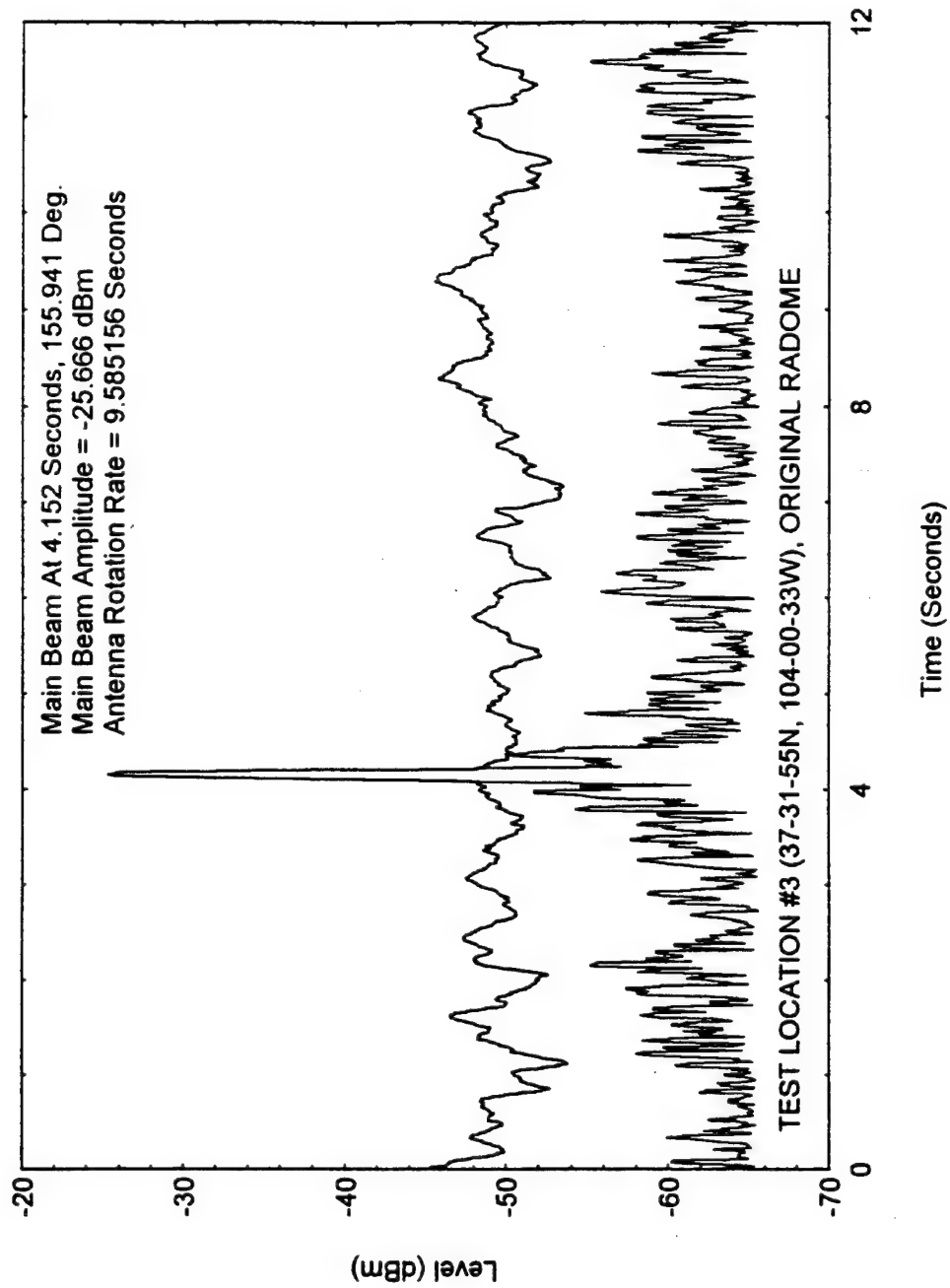
TRINIDAD, CO HORIZONTAL BEACON PLOT



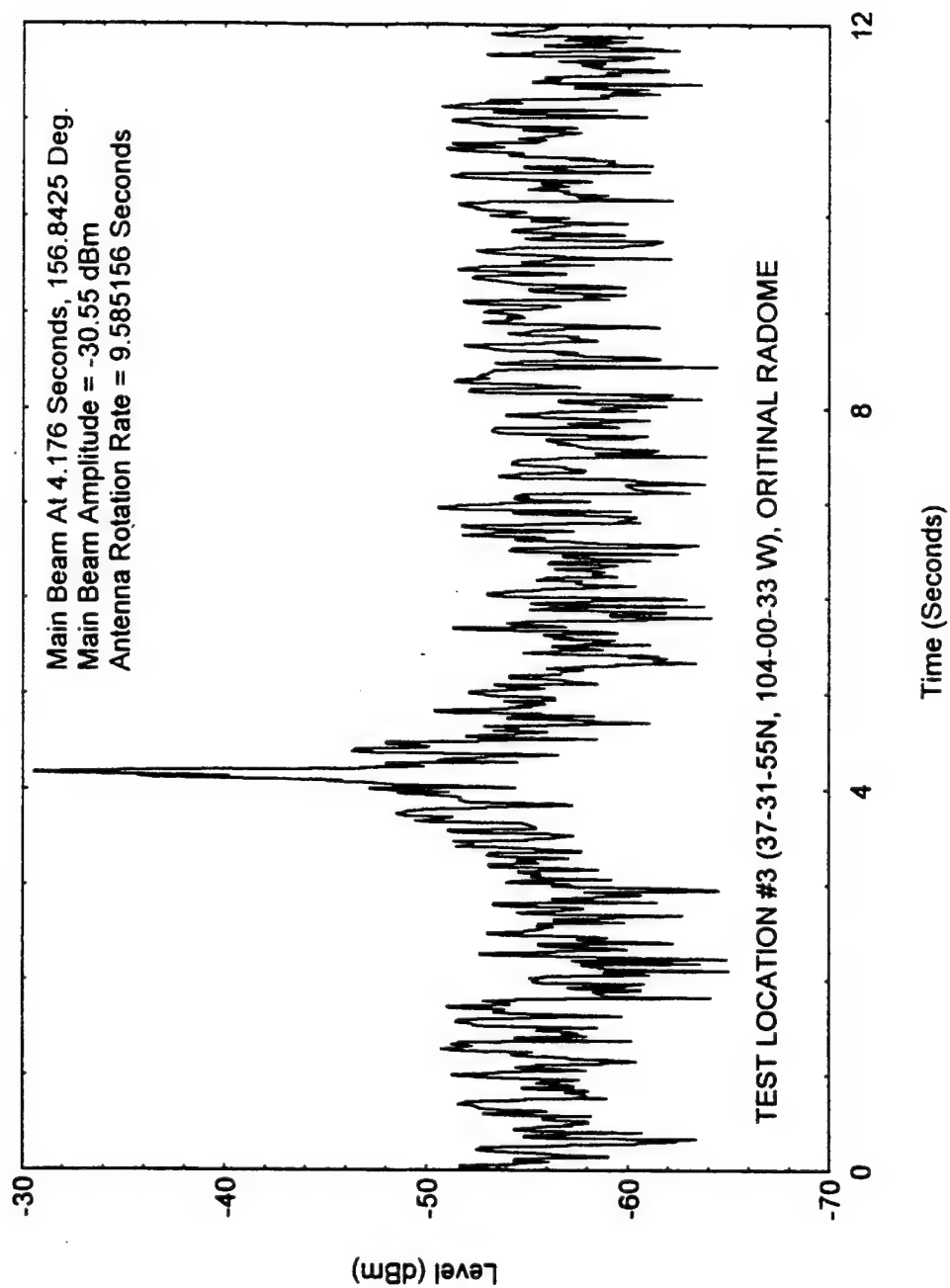
TRINIDAD, CO HORIZONTAL RADAR PLOT



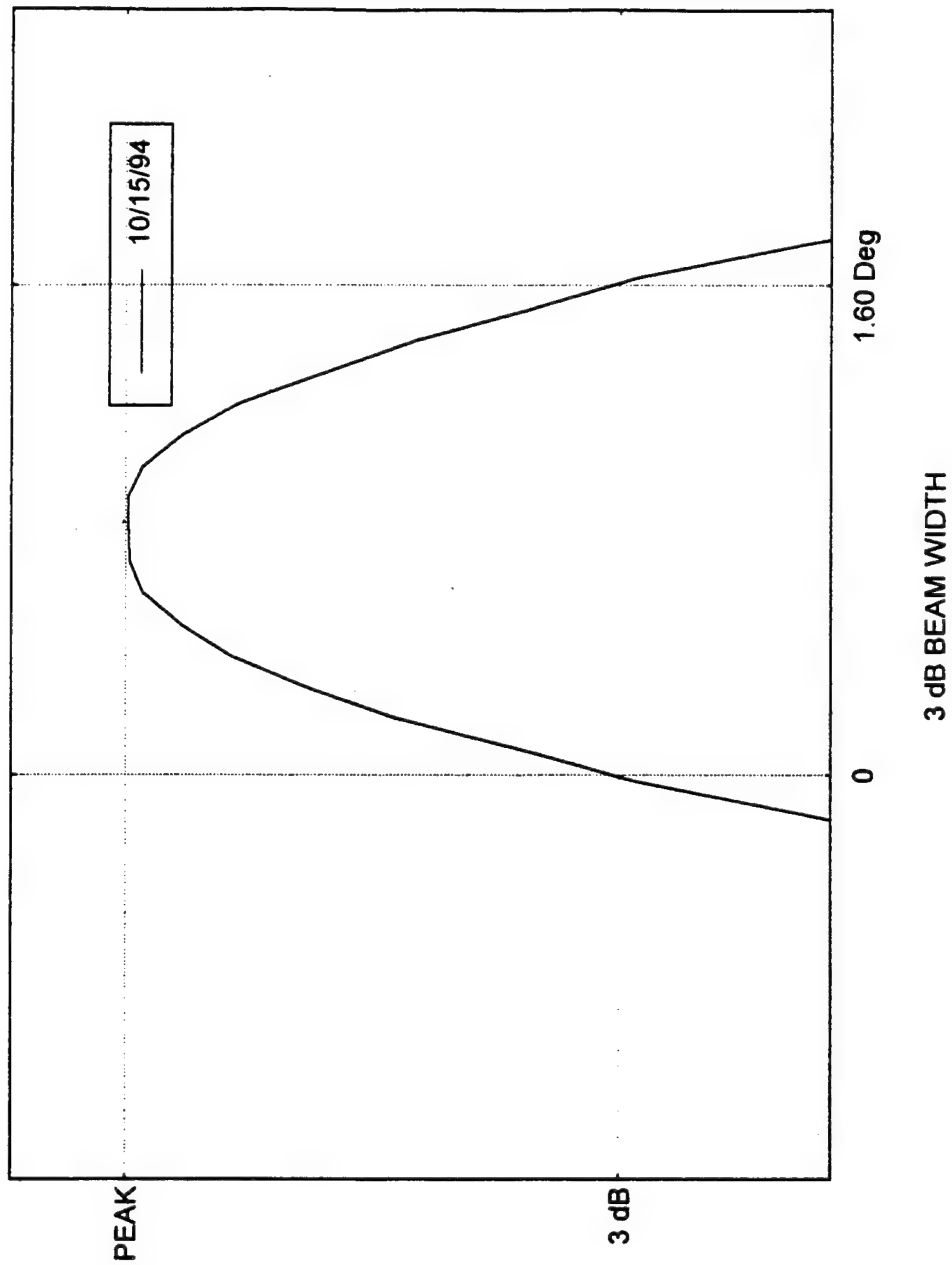
TRINIDAD, CO HORIZONTAL BEACON PLOT



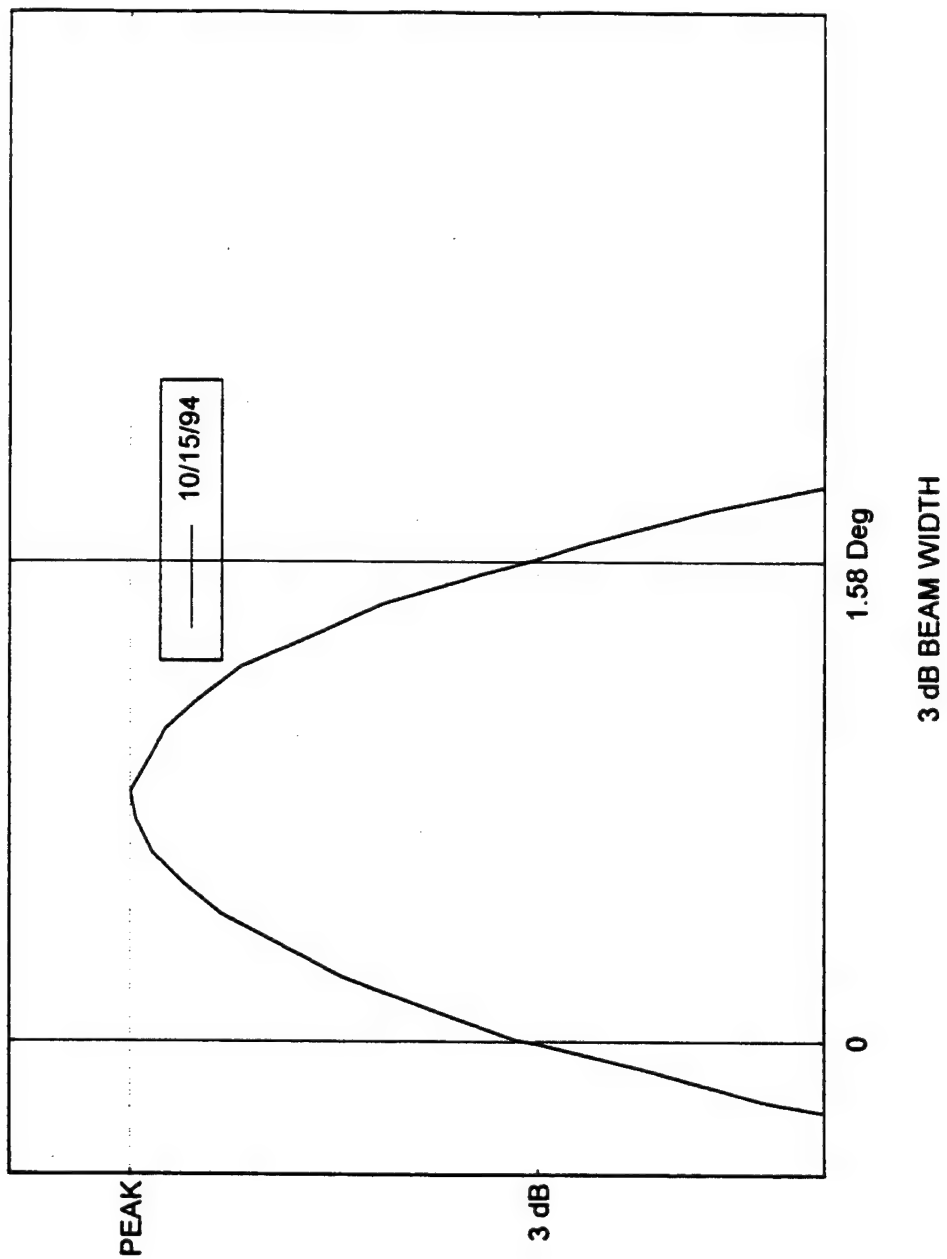
TRINIDAD, CO HORIZONTAL RADAR PLOT



TRINIDAD CO TEST LOC #1, 1030 MHZ, BEAM WIDTH (ORIGINAL RADOME)



TRINIDAD CO TEST LOC #2, 1030 MHZ, BEAM WIDTH (ORIGINAL RADOME)

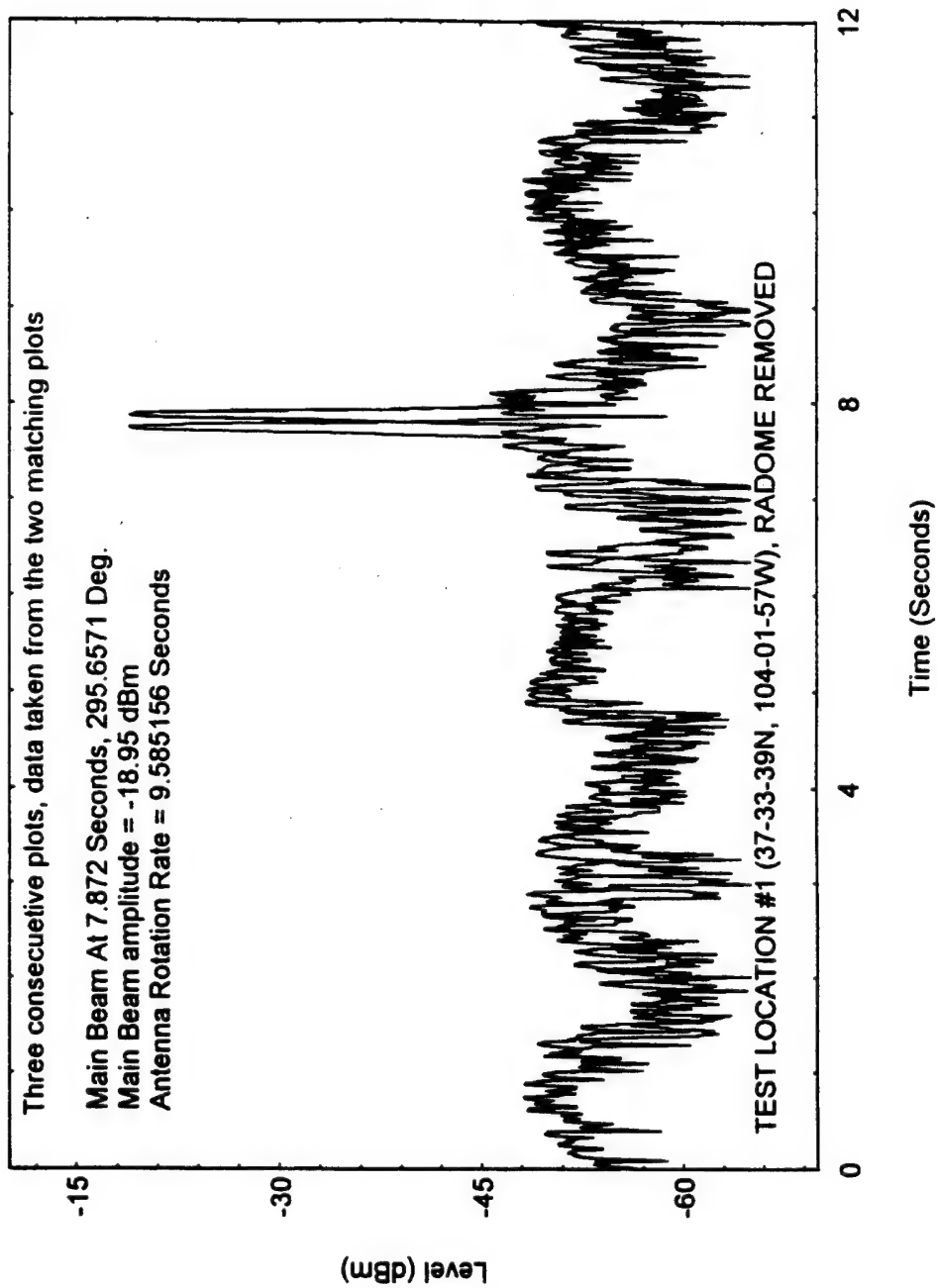


ATTACHMENT 2

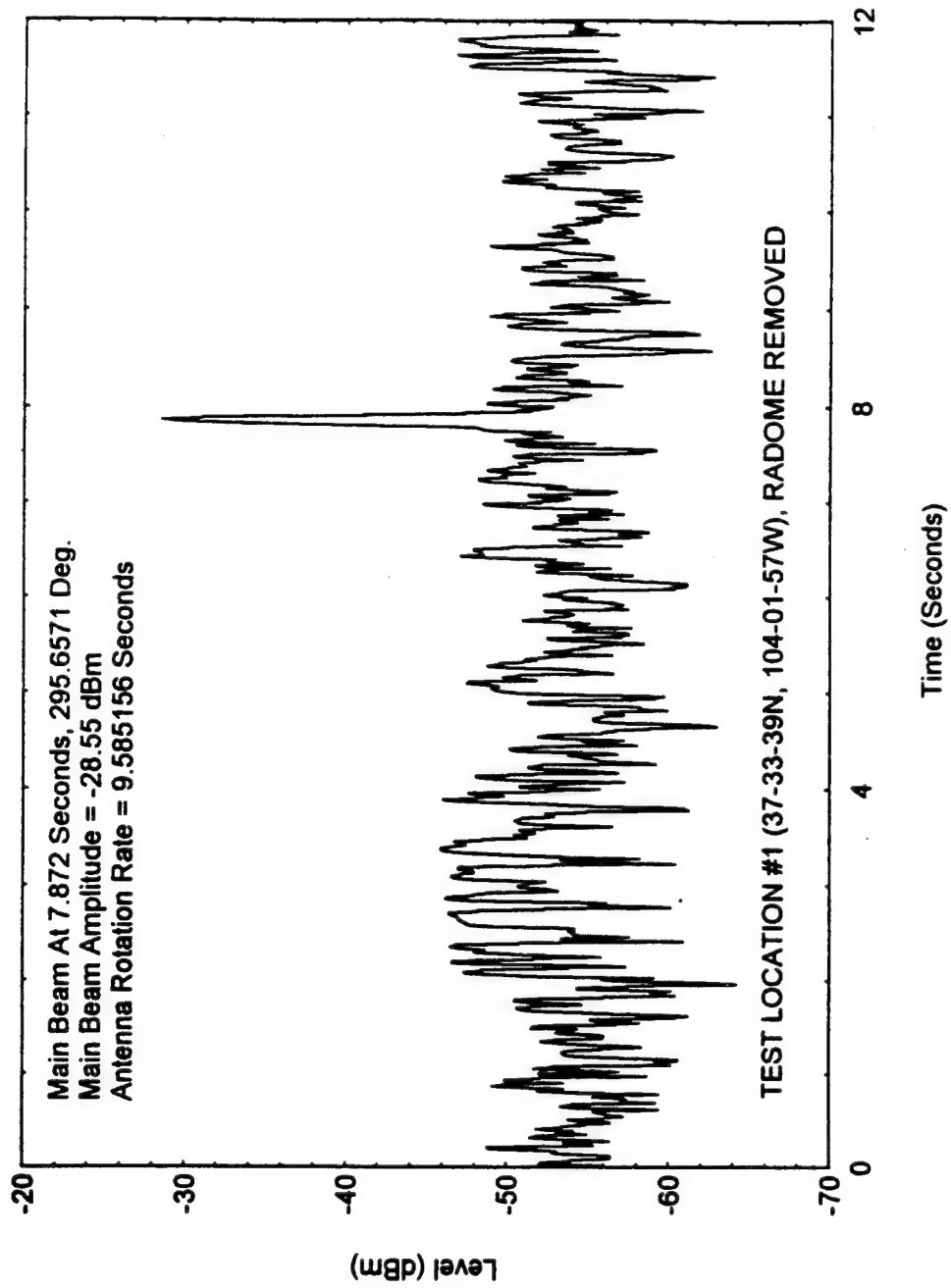
RADOME REMOVED

360° Horizontal Plots
Beam Width Plots
Vertical Plots (Solars)

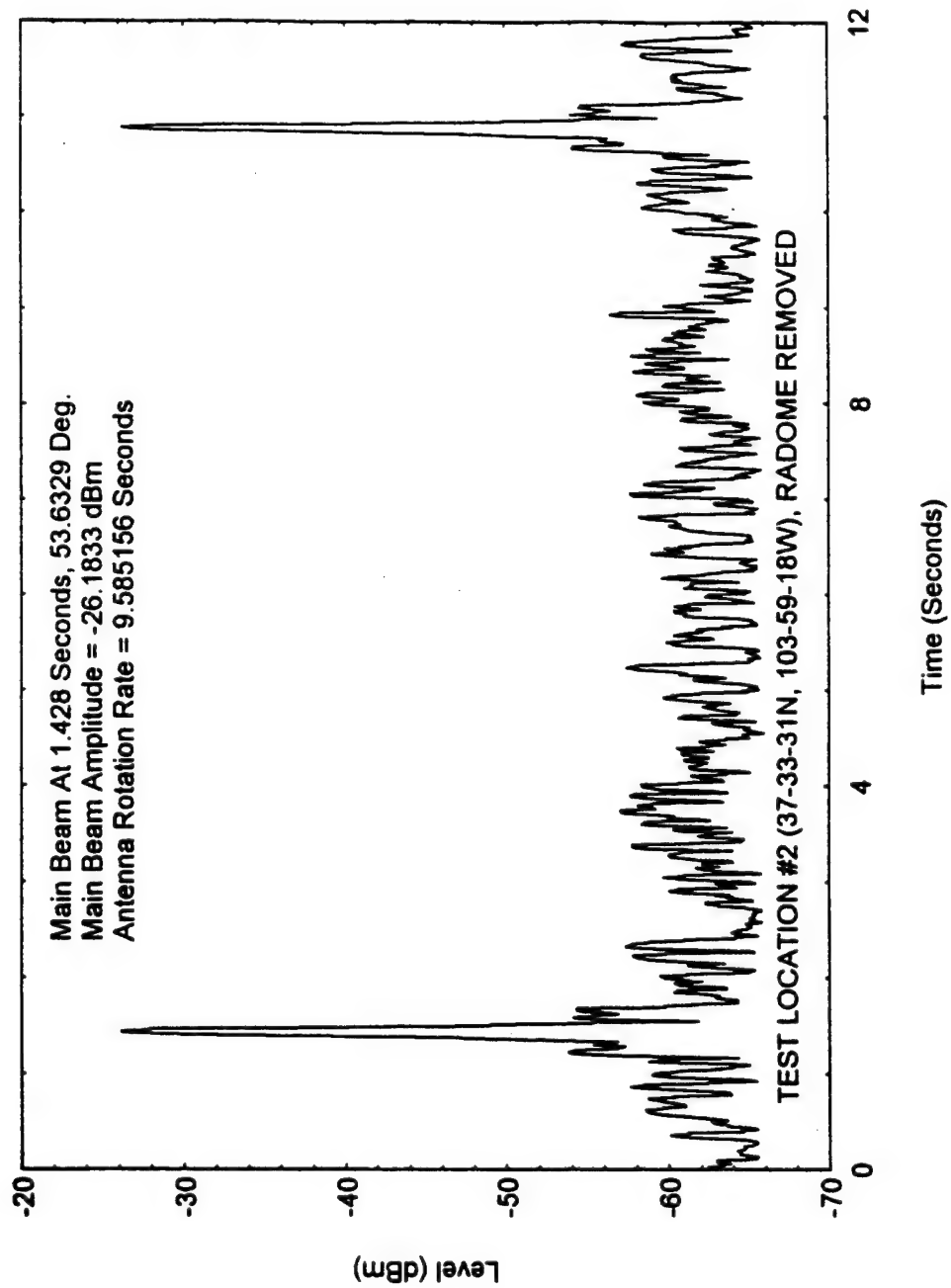
TRINIDAD, CO HORIZONTAL BEACON PLOTS



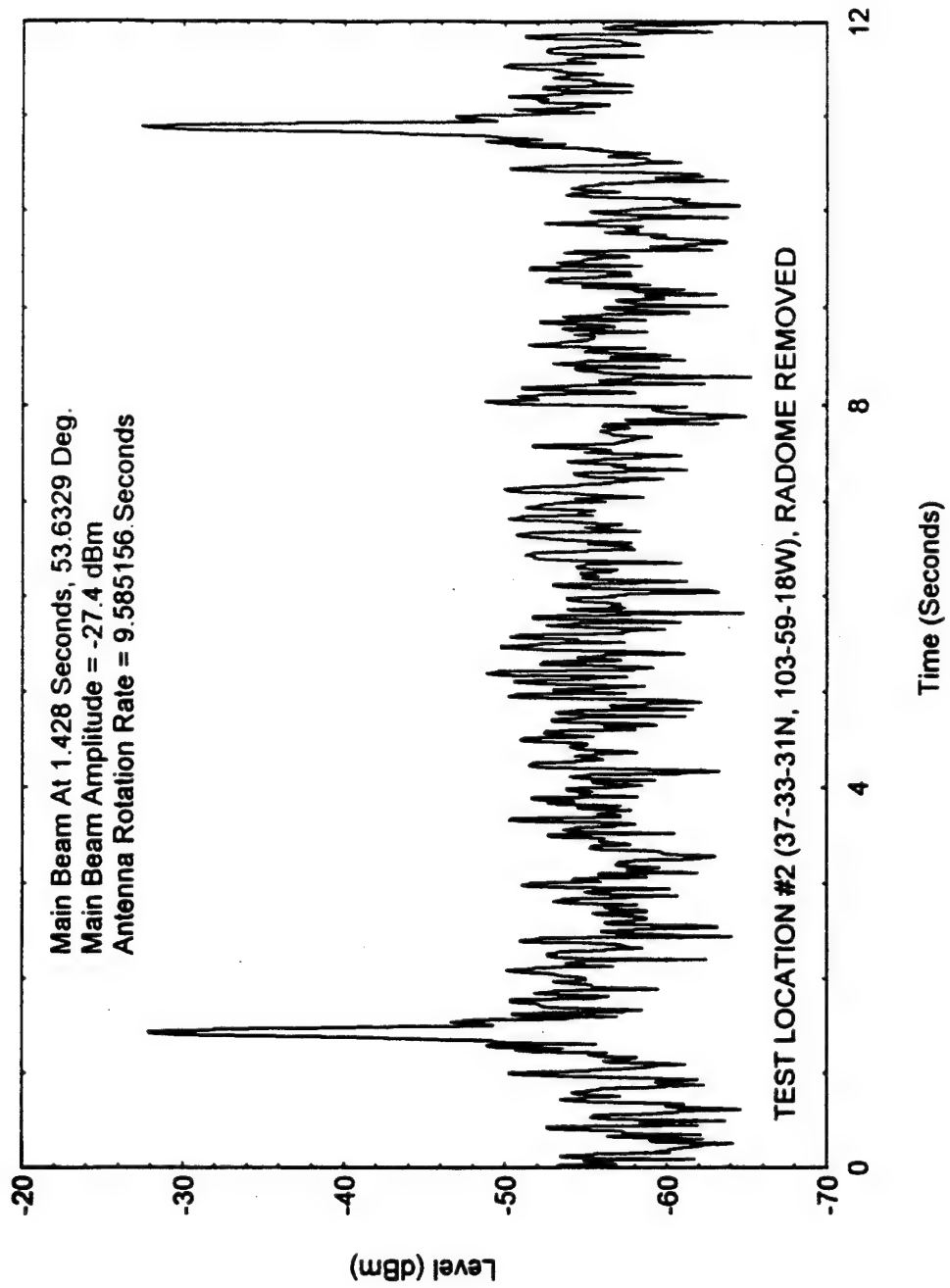
TRINIDAD, CO HORIZONTAL RADAR PLOT



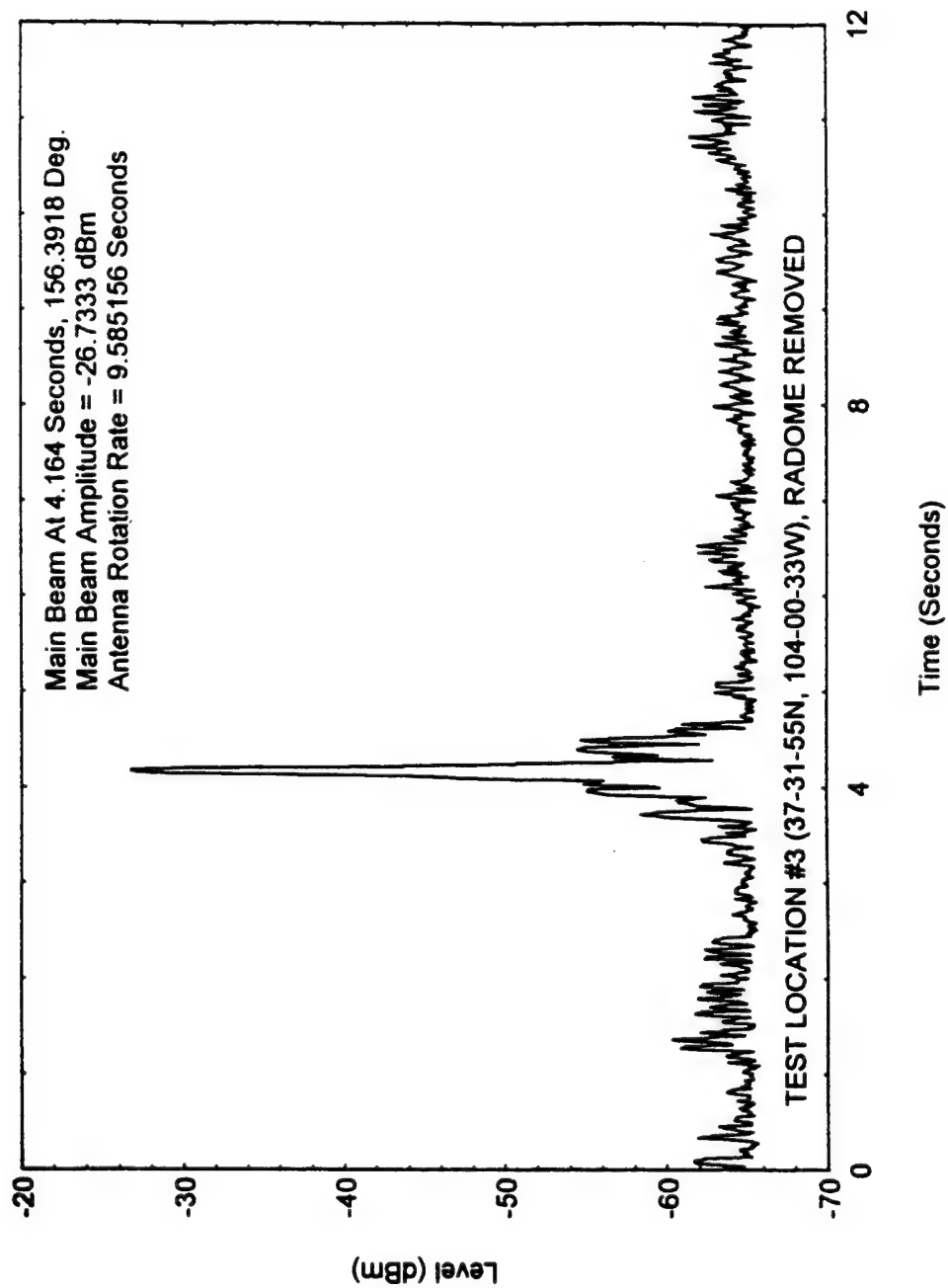
TRINIDAD, CO HORIZONTAL BEACON PLOT



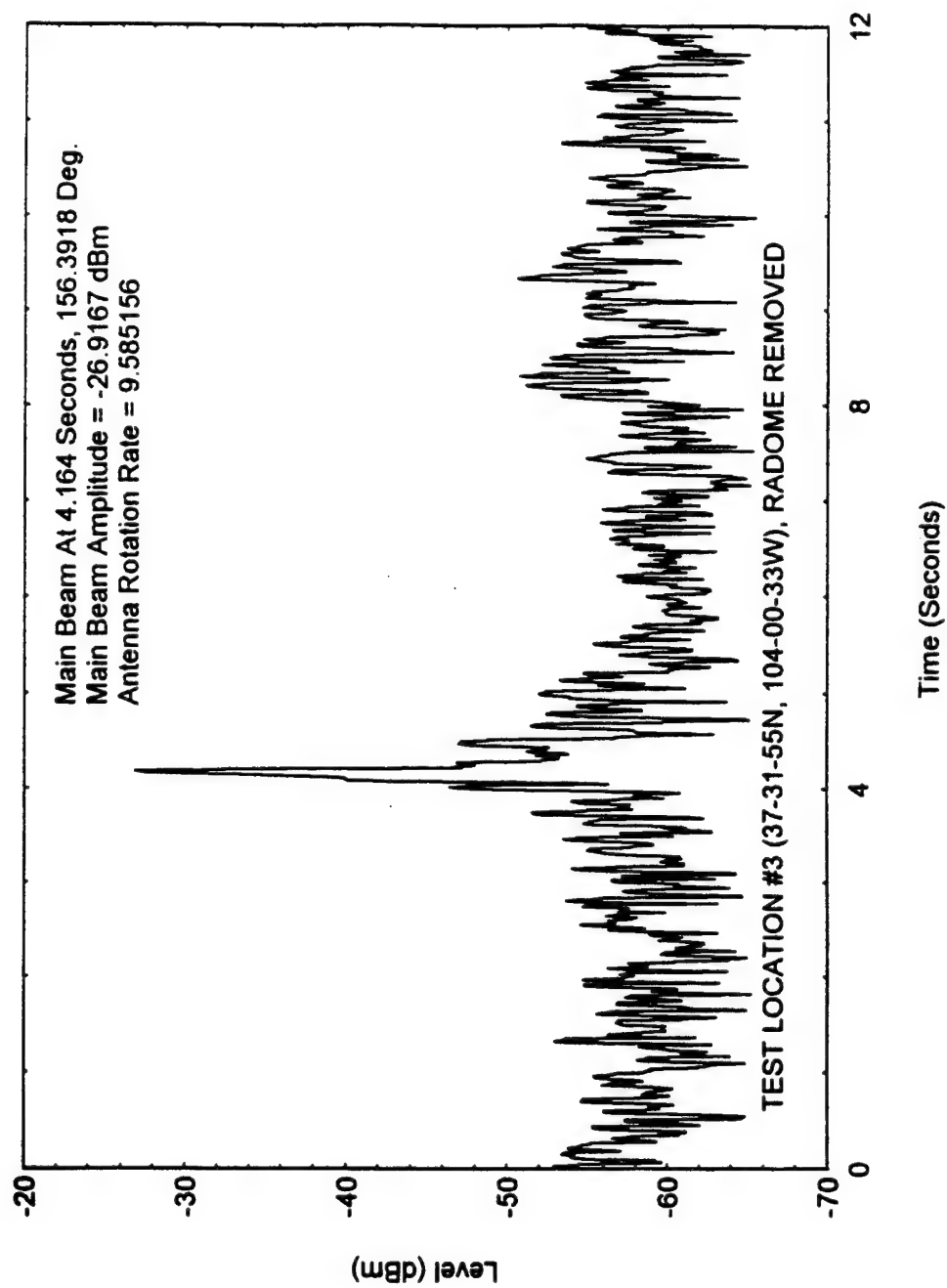
TRINIDAD, CO HORIZONTAL RADAR PLOT



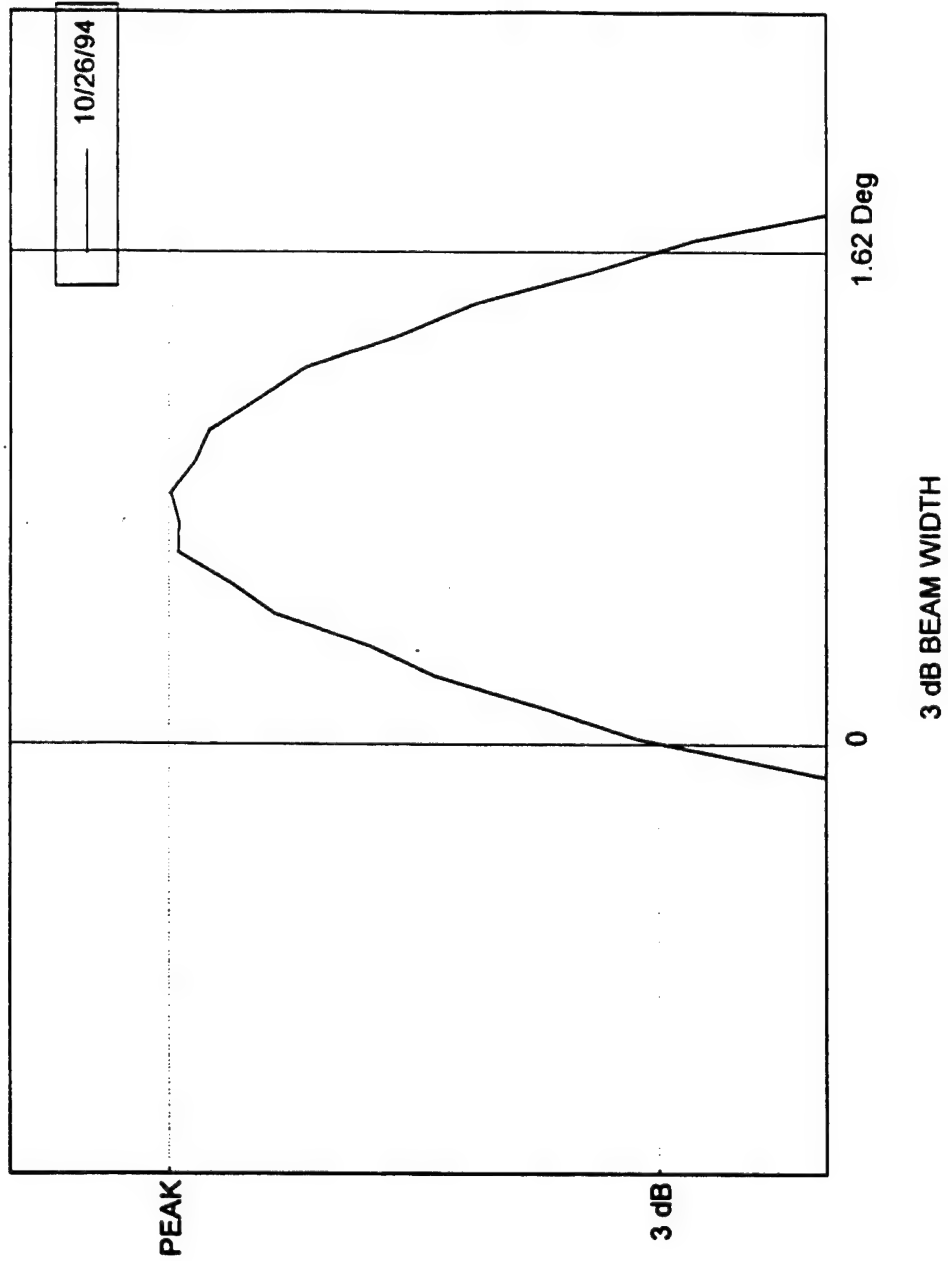
TRINIDAD, CO HORIZONTAL BEACON PLOT



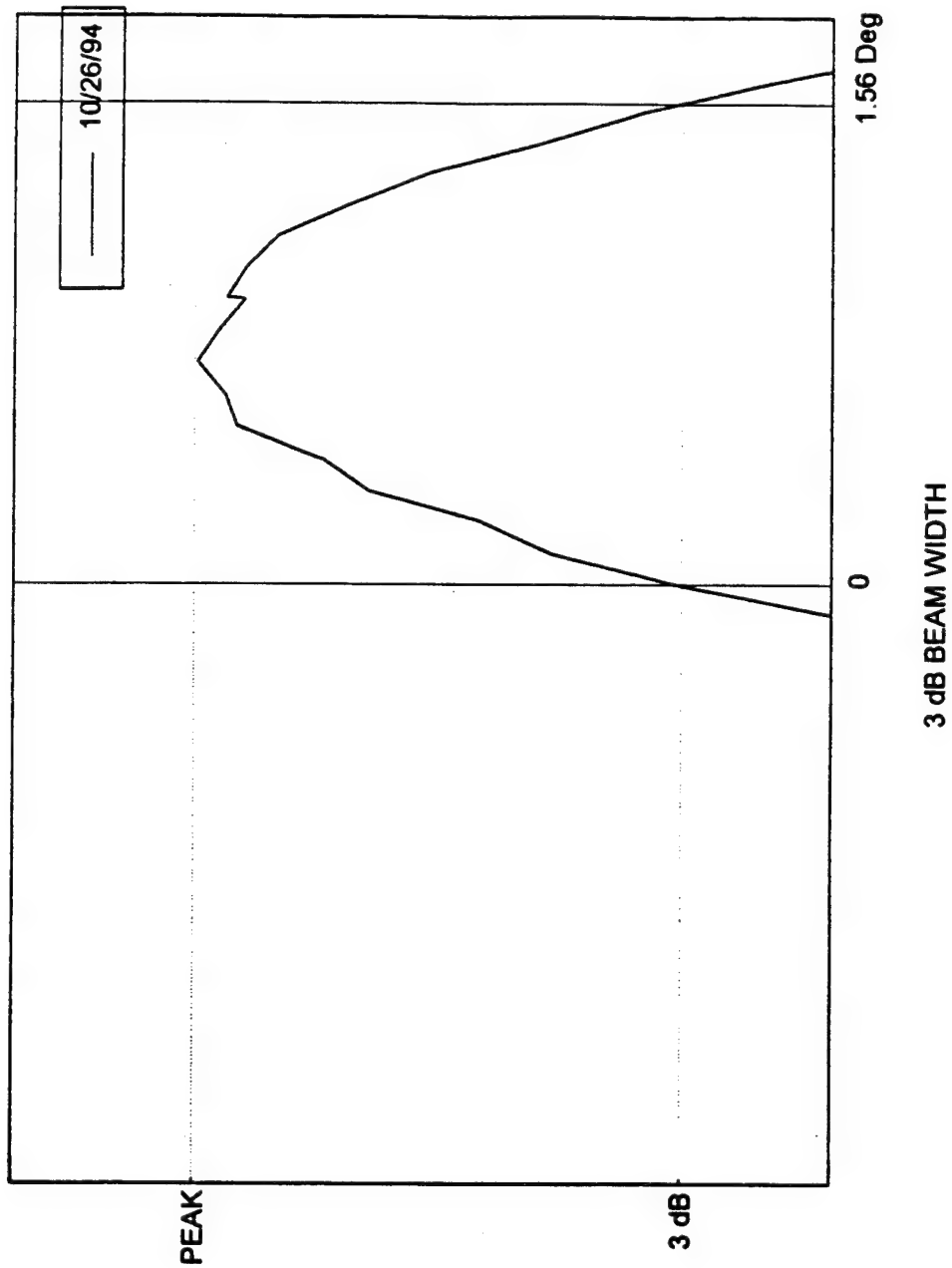
TRINIDAD, CO HORIZONTAL RADAR PLOT



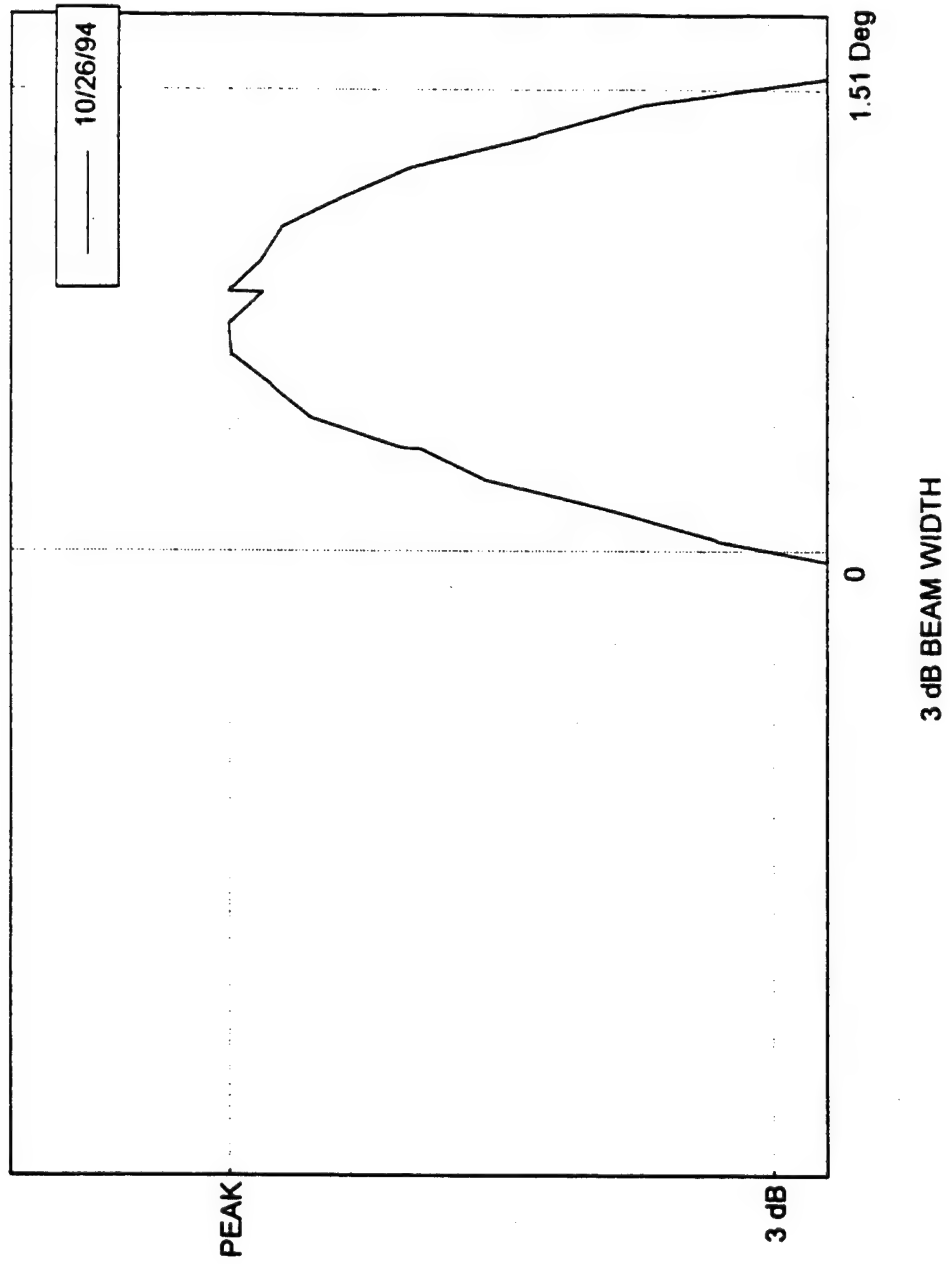
TRINIDAD CO TEST LOC#1, 1030 MHZ, BEAM WIDTH (NO RADOME)



TRINIDAD CO TEST LOC#2, 1030 MHZ, BEAM WIDTH (NO RADOME)



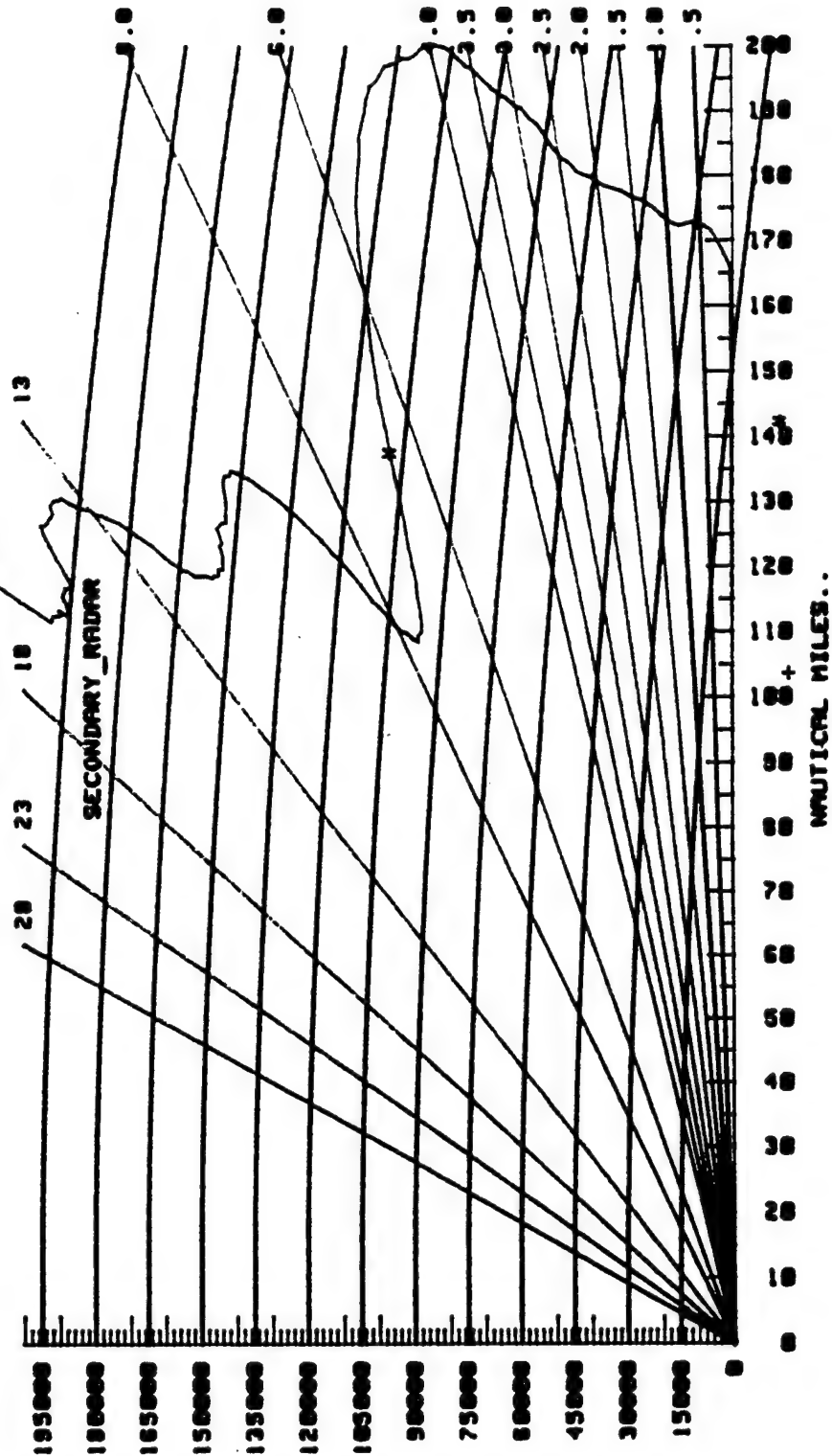
TRINIDAD CO TEST LOC#3, 1030 MHZ, BEAM WIDTH (NO RADOME)



DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 4.84 Deg
 3DB points are at -0.89 AND 6.59 Deg
 6DB points are at -1.48 AND 22.00 Deg
 3DB BANDWIDTH = 7.48 Deg

+ *Yummy*
 DATAFILE: S_RAD1094A



EVALUATE TILT AT 1.5
 LOCATION TRINIDAD/1325

72-MV

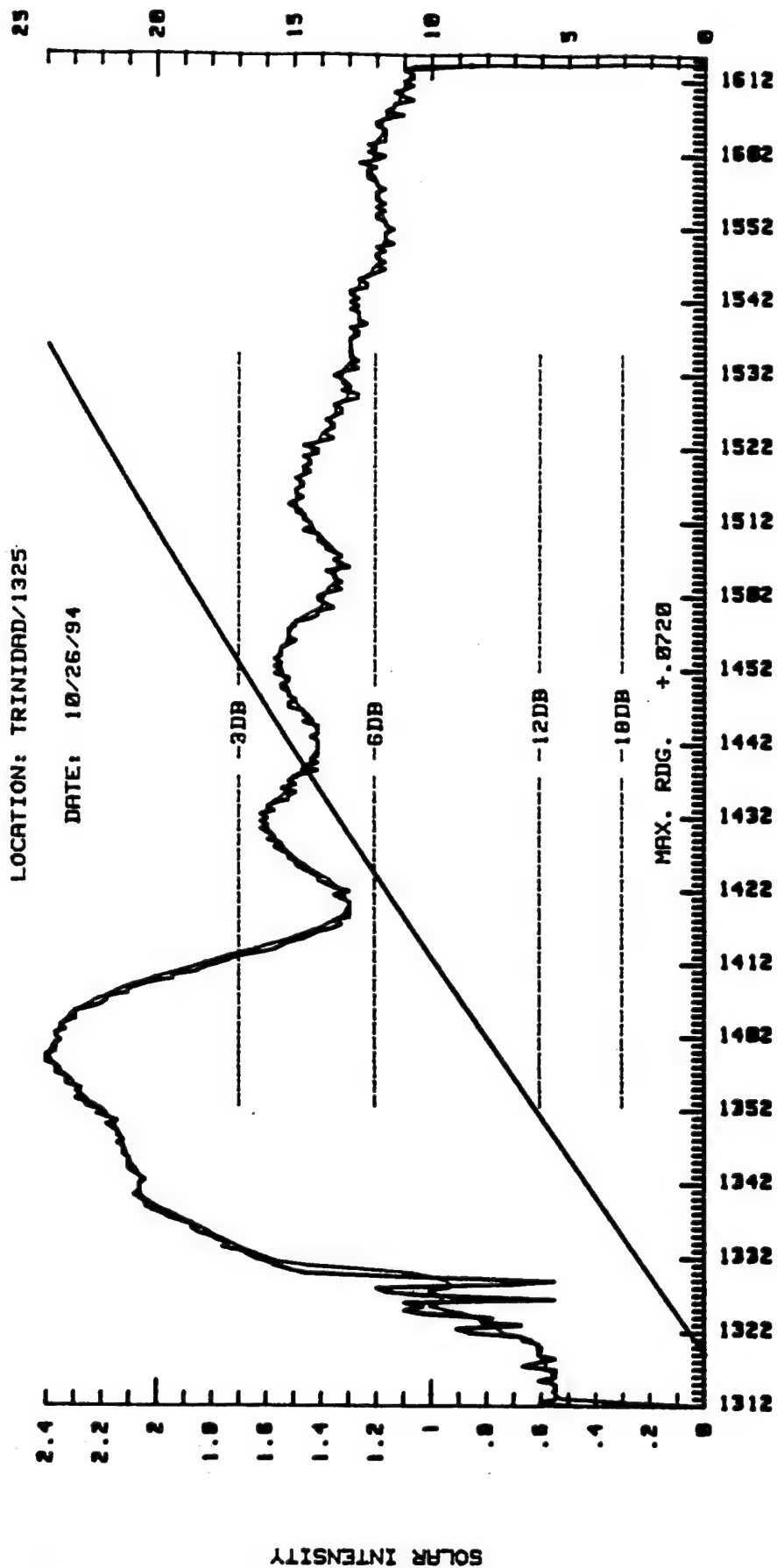
SECONDARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1094A

LOCATION: TRINIDAD/1325

DATE: 10/26/94

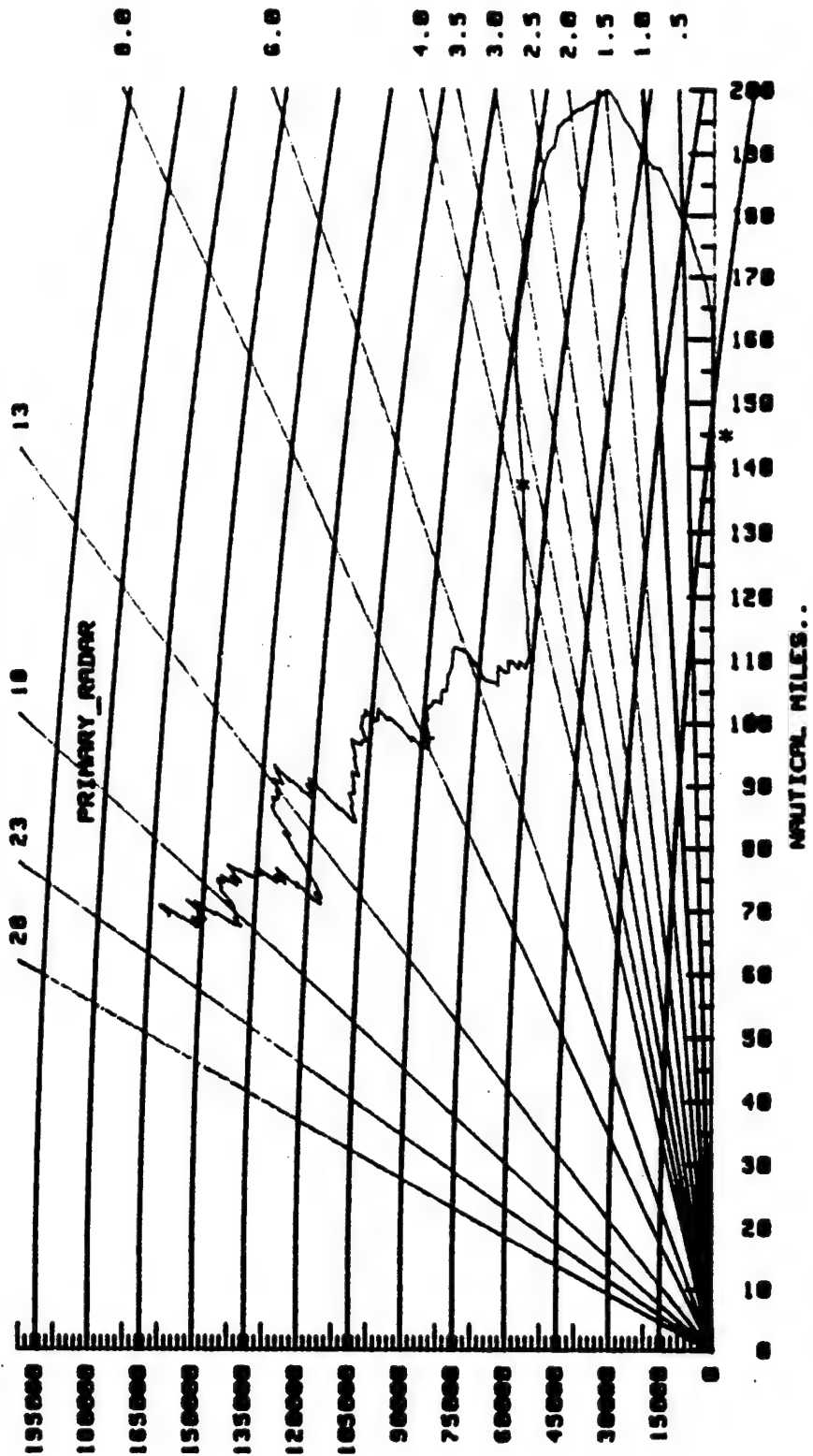


LONG. 104 0 51
LAT. 37 32 50

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 1.45 Deg
3DB points are at -0.23 AND 3.76 Deg
6DB points are at -1.88 AND 7.84 Deg
3DB BANDWIDTH = 4.00 Deg

DATAFILE: S_TAD1634A



EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325

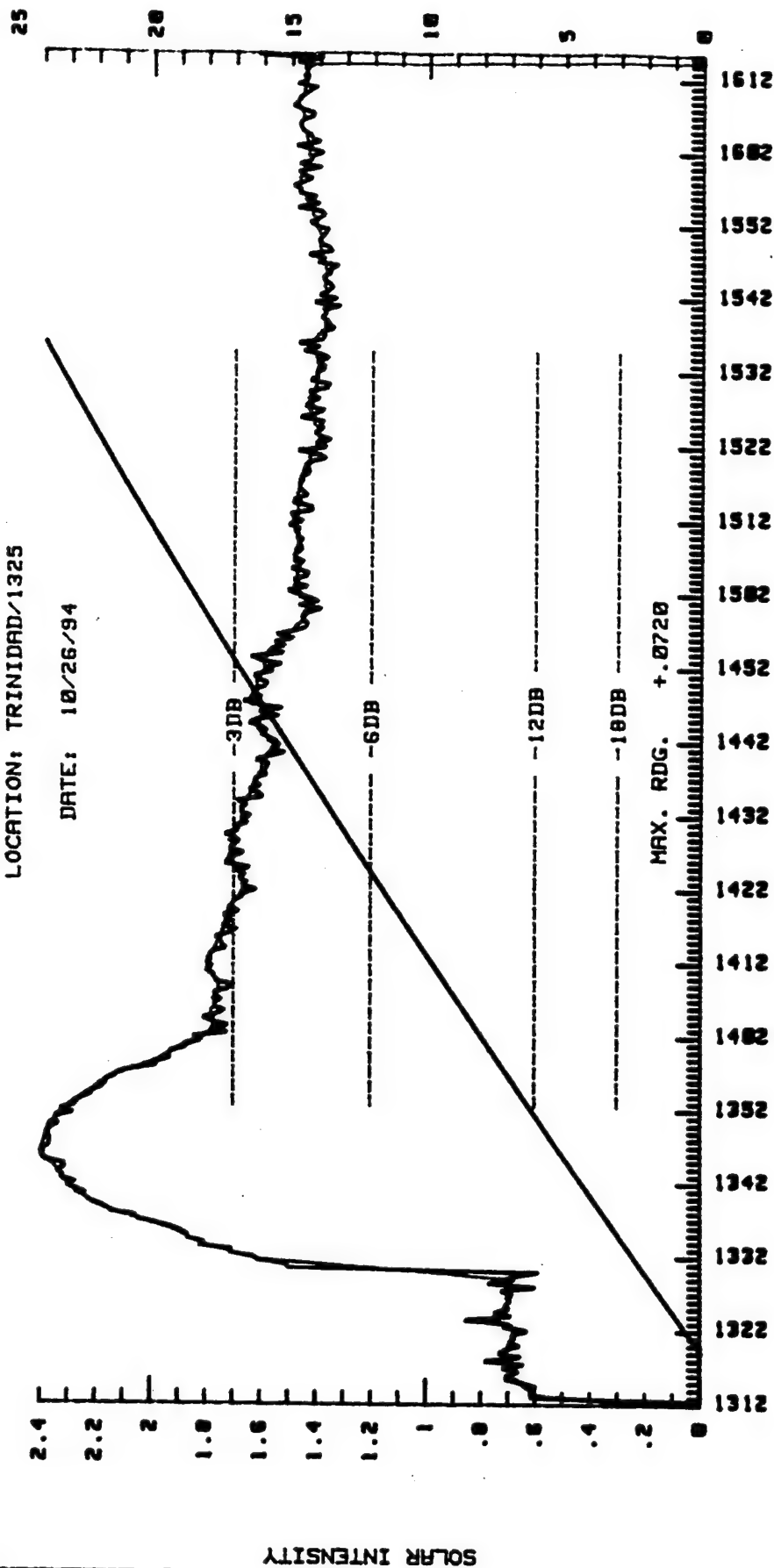
PRIMARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1094A

LOCATION: TRINIDAD/1325

DATE: 10/26/94



DATAFILE: S_TAD1034A

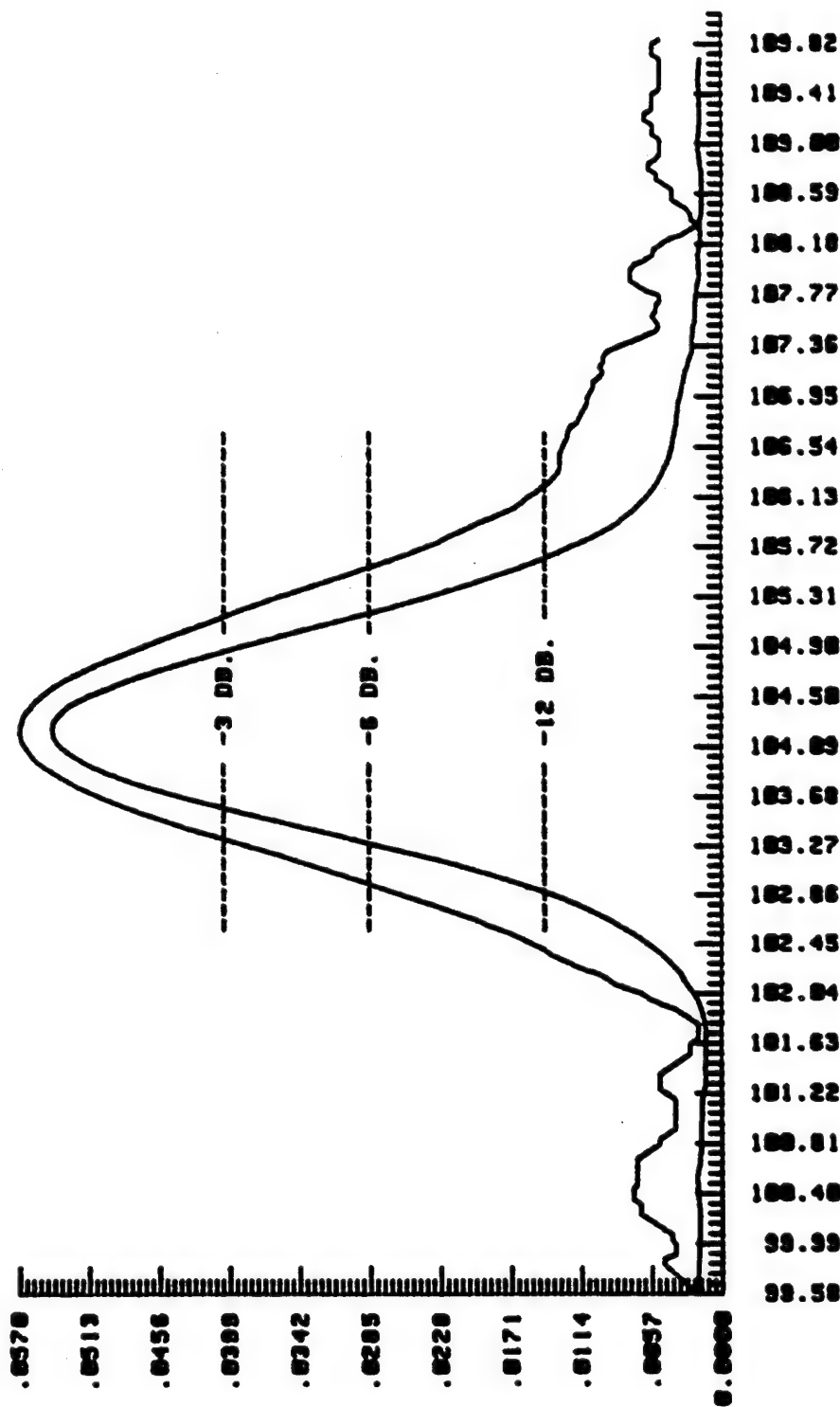
DATE: 10/26/94

AZIMUTHAL CUT

SYSTEM TYPE: ARSR2/1.5

SCAN PERIOD: 9.62 SEC.

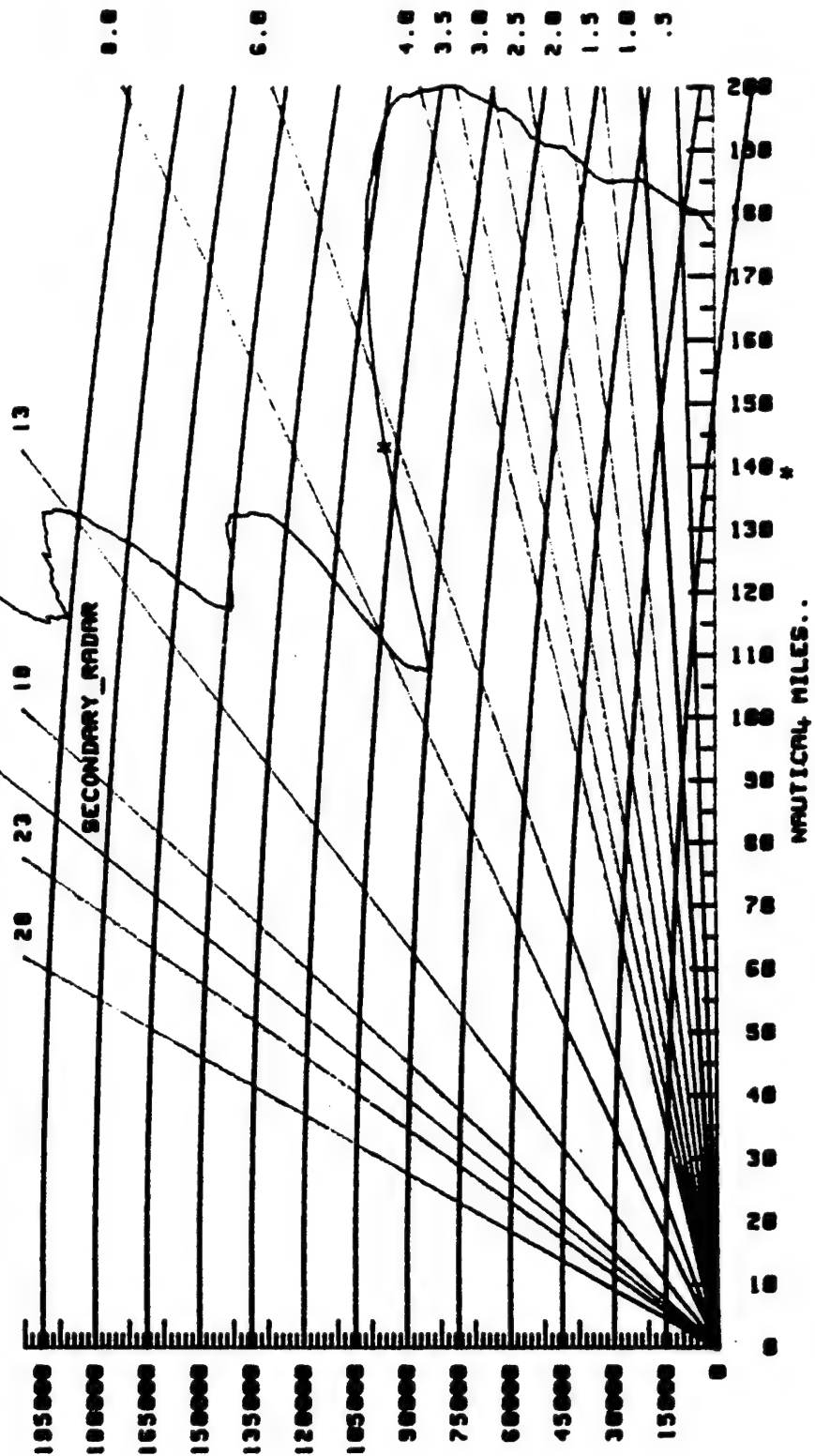
COMPUTED AZ 109.97



DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 3.51 Deg
3DB points are at 6.25 AND -1.44 Deg
6DB points are at 22.17 AND -2.48 Deg +
3DB BANDWIDTH = 7.68 Deg

DATAFILE: S_TAD18945



EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325

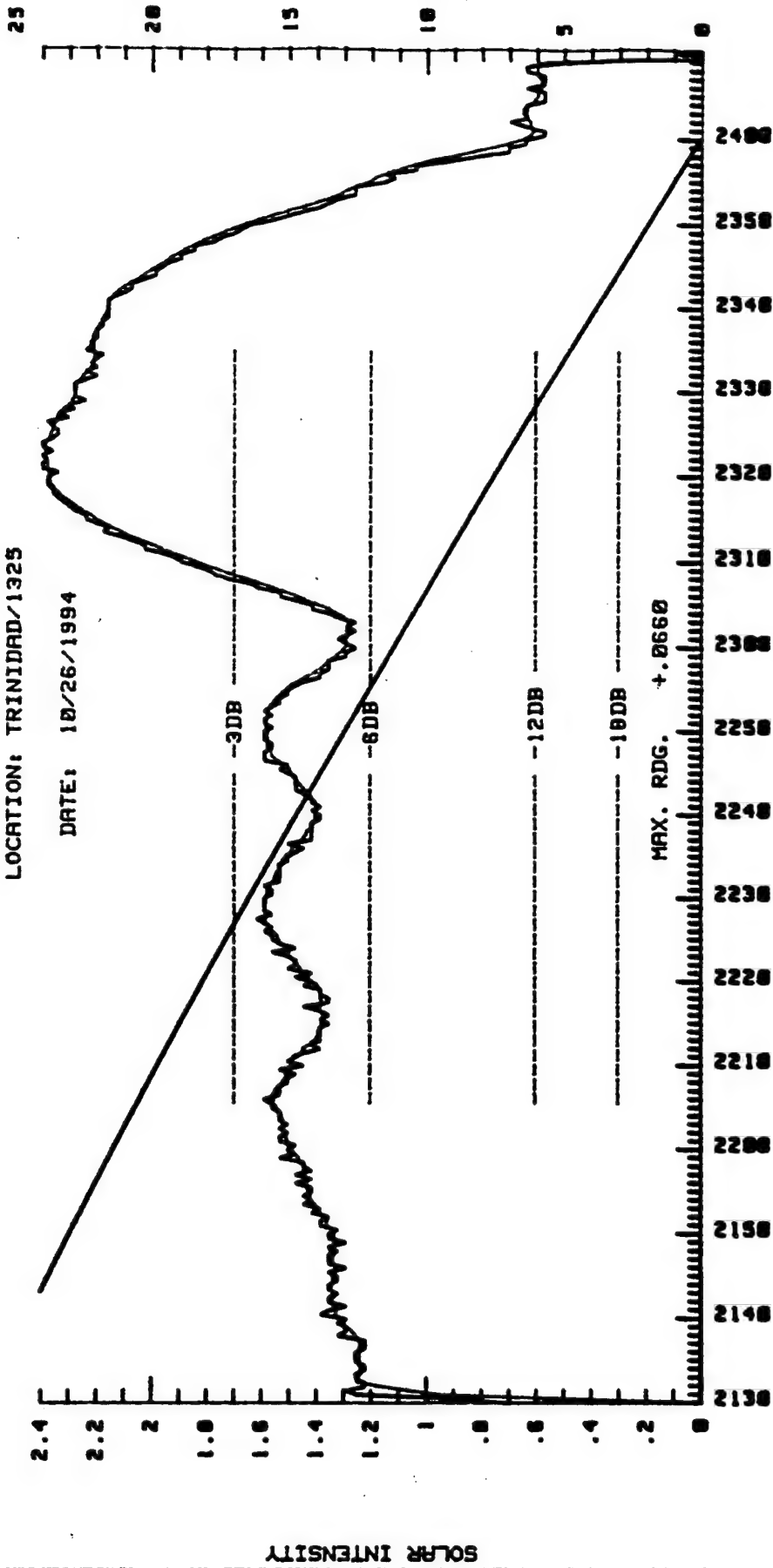
SECONDARY_RADAR

SYSTEM: ARSR-2/1.5

DATAFILE: S_TAD1094B

LOCATION: TRINIDAD/1325

DATE: 10/26/1994



DATAFILE: S_RAD10948

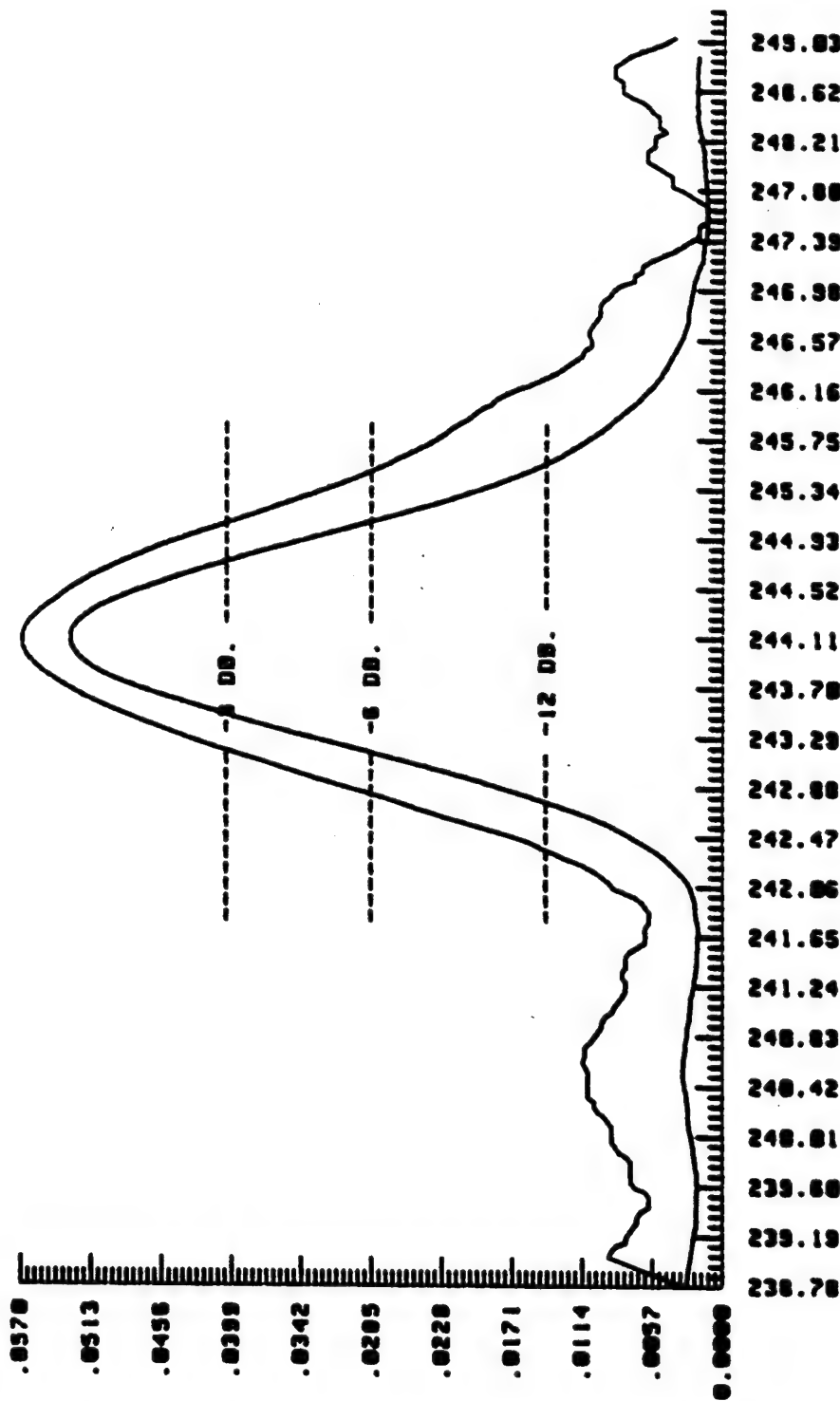
DATE: 10/26/1994

SYSTEM TYPE: RMSR-2/1.5

SCAN PERIOD: 9.60 SEC.

AZIMUTHAL CUT

COMPUTED AZ 249.83



3 DB. B/W 1.84 DEG.

----- AZ. DEGREES.-----

6 DB. B/W

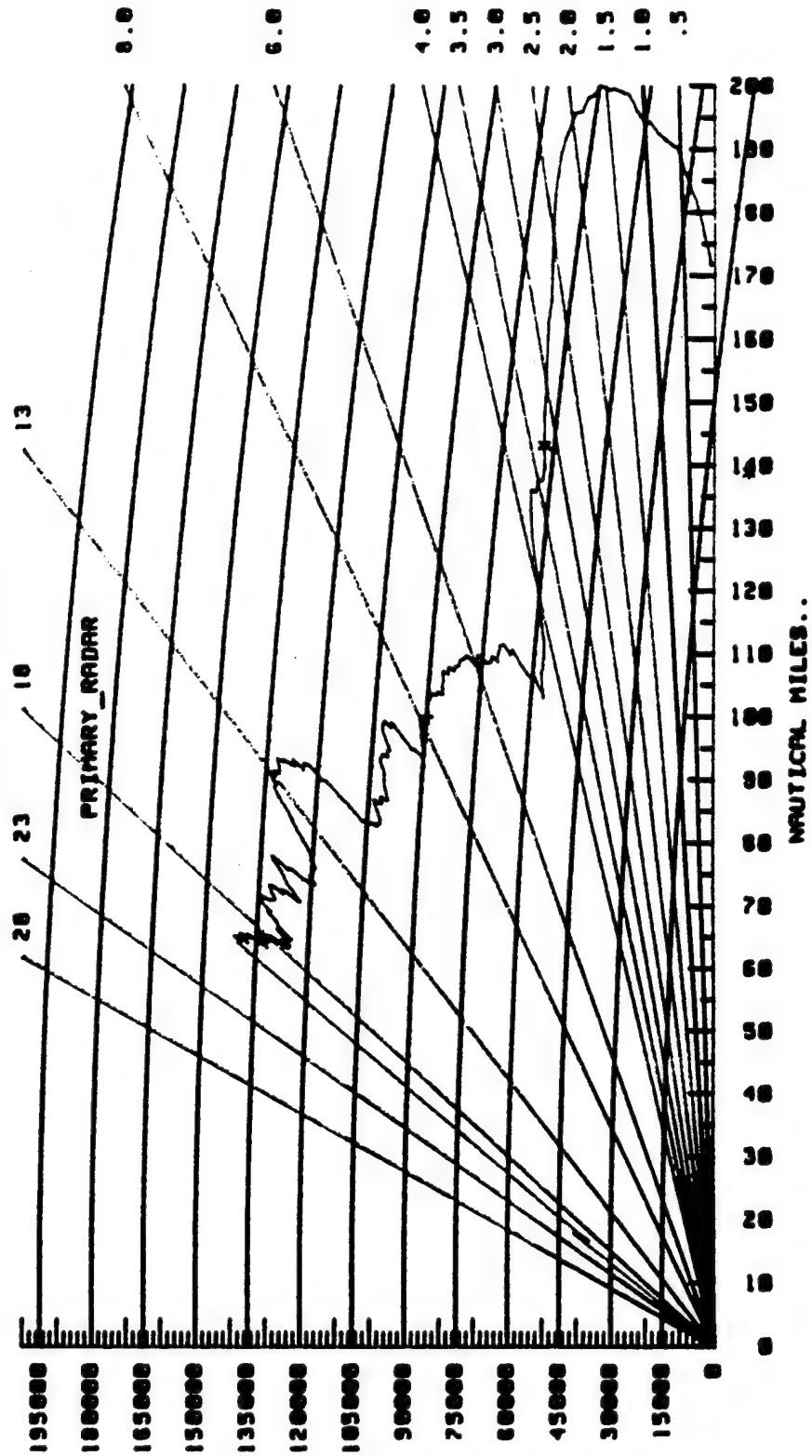
2.66 DEG.

TRINIDAD/1325

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 1.57 Deg
3DB points are at 3.23 AND -1.68 Deg
6DB points are at 7.78 AND -1.34 Deg
3DB BANDWIDTH = 3.92 Deg

DATAFILE: S_TAD1894B



EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325

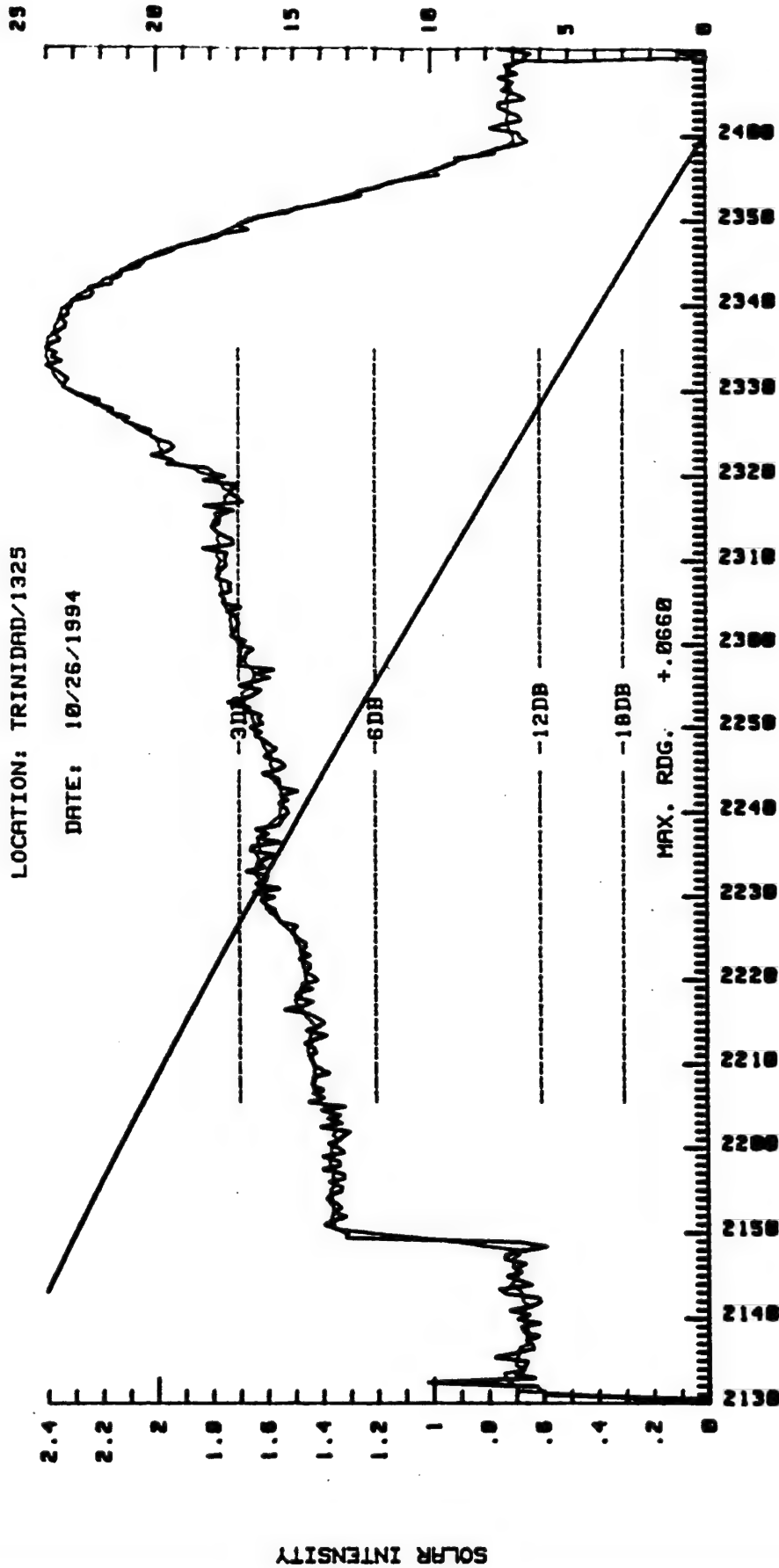
PRIMARY_RADAR

SYSTEM: ARSR-2/1.5

DATAFILE: S_TAD1094B

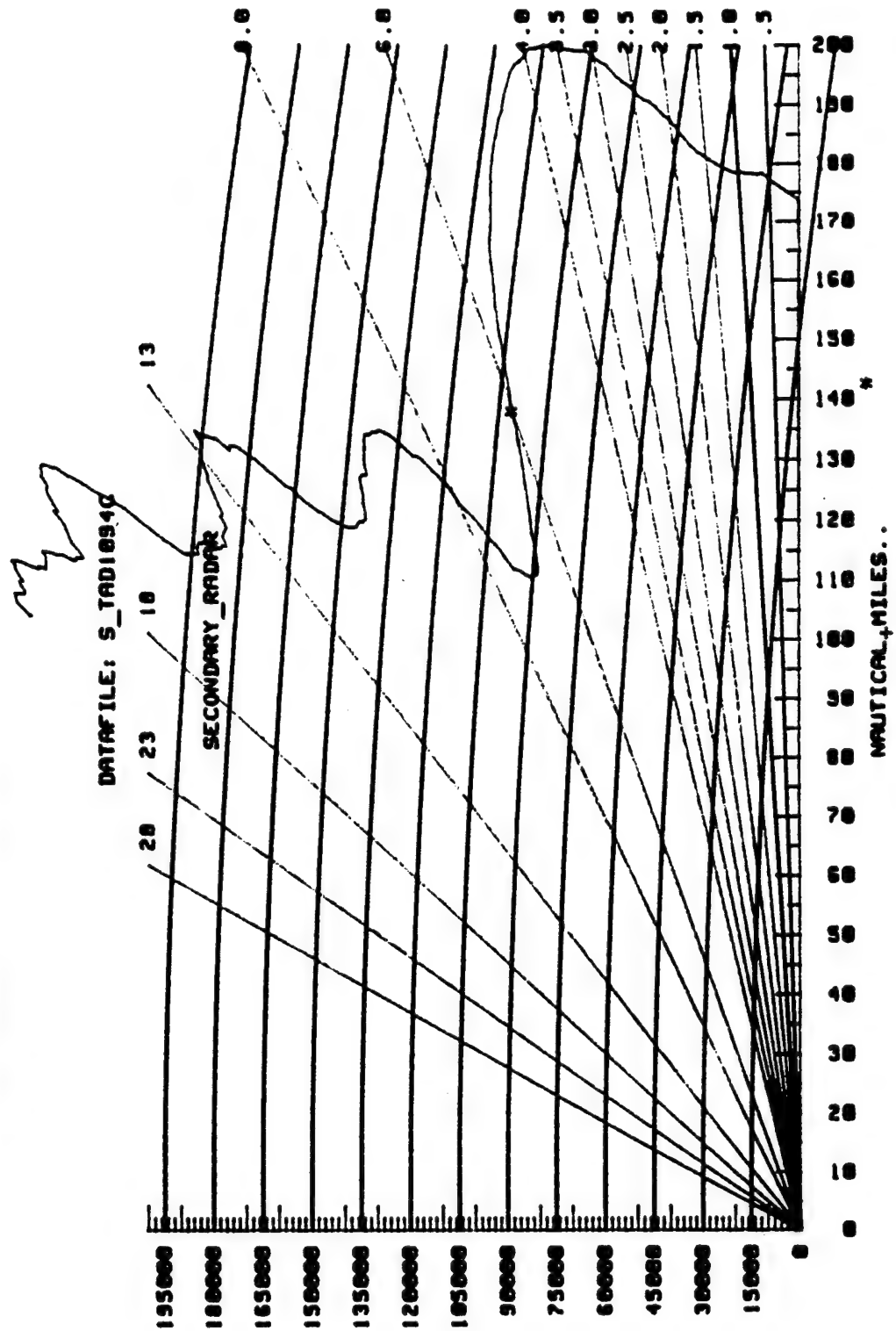
LOCATION: TRINIDAD/1325

DATE: 10/26/1994



DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 3.65 Deg
3DB points are at -1.37 AND 6.01 Deg
6DB points are at -2.98 AND 23.18 Deg.
3DB BANDWIDTH = 7.35 Deg



EVALUATE TILT AT 1.5
LOCATION TRINIDAD CO/1325

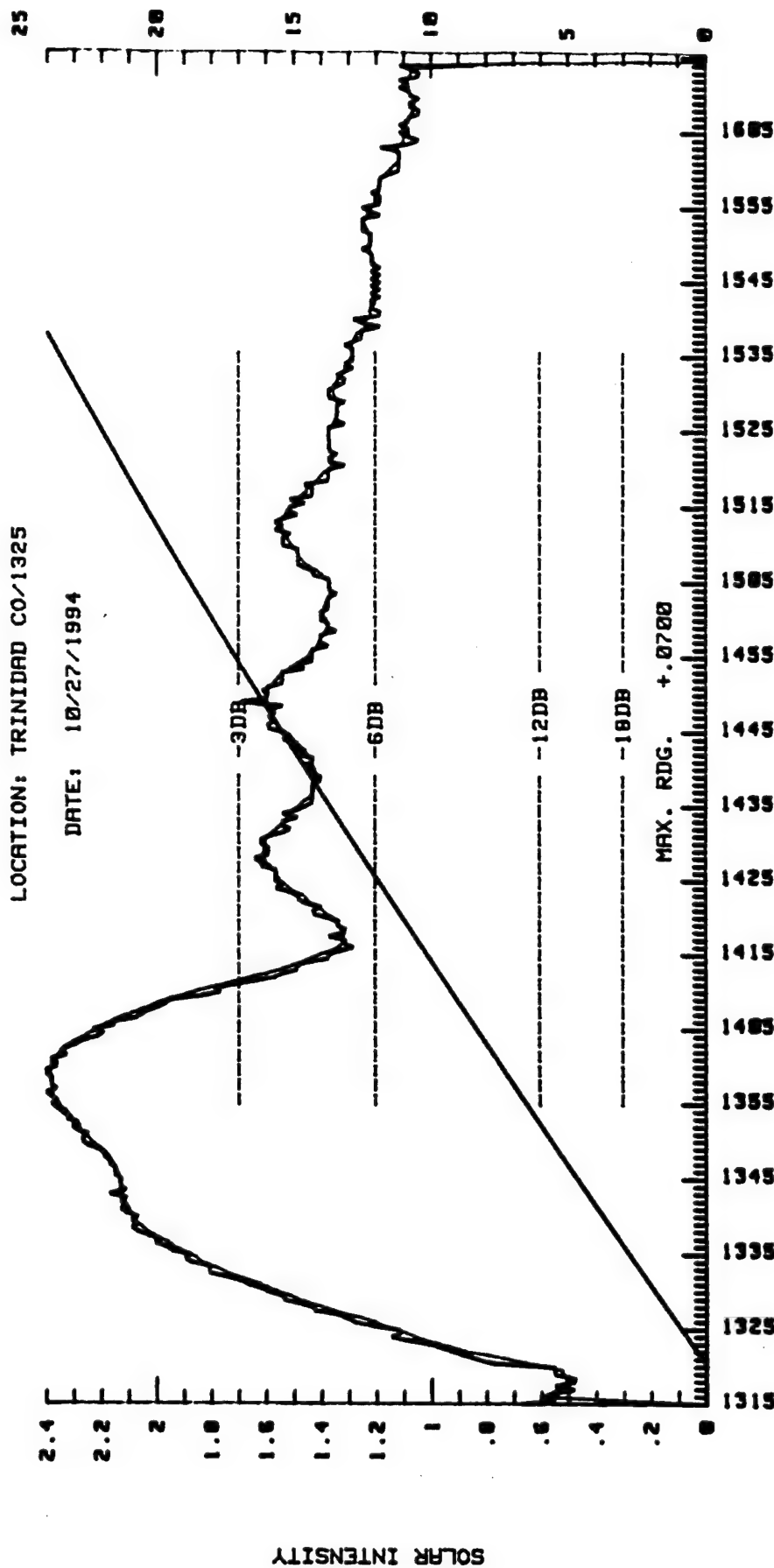
SECONDARY_RADAR

SYSTEM: 1.5

DATAFILE: S_TADI094C

LOCATION: TRINIDAD CO/1325

DATE: 10/27/1994



DATAFILE: S_TAD1094C

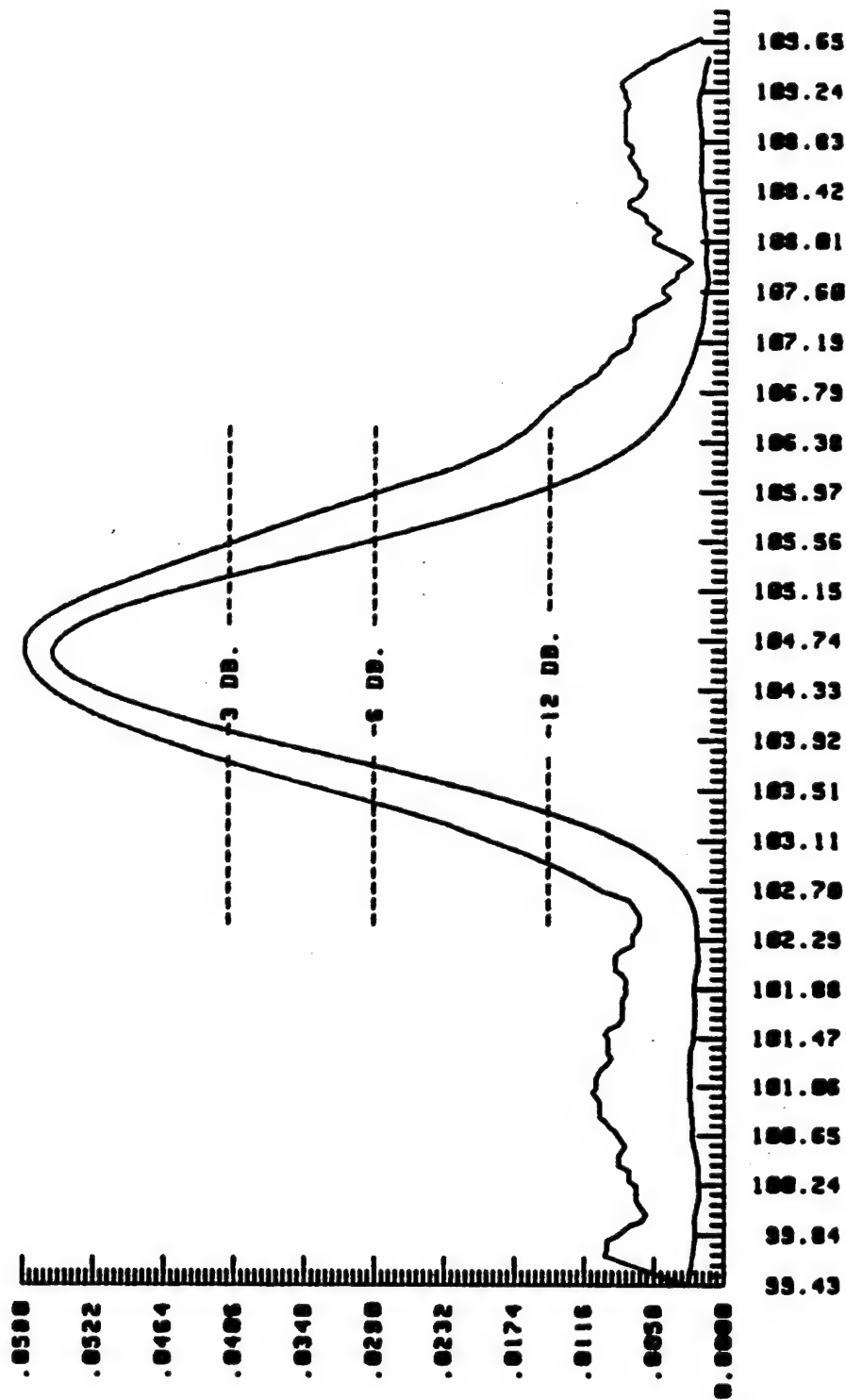
DATE: 10/27/1994

AZIMUTHAL CUT

SYSTEM TYPE: 1.3

SCAN PERIOD: 9.63 SEC.

COMPUTED AZ 110.40

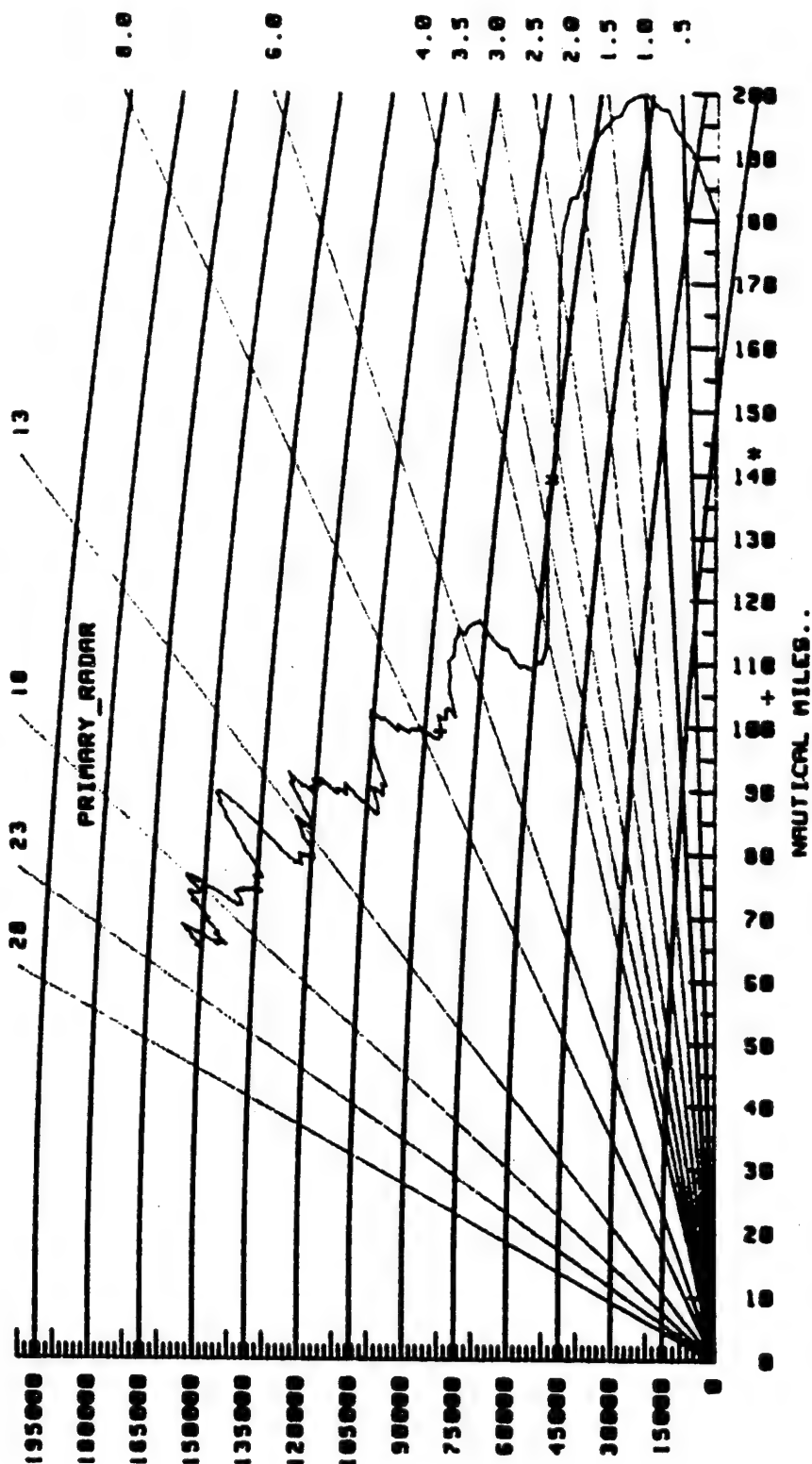


3 DB. B/W 1.80 DEG. ----- AZ. DEGREES ----- 6 DB. B/W 2.53 DEG.

TRINIDAD CO/1325

ANTENNA ELECTRICAL TILT IS .97 Deg
 3DB points are at -.71 AND 3.13 Deg
 6DB points are at -1.37 AND 7.45 Deg
 3DB BANDWIDTH = 3.96 Deg

DATAFILE: S_TADI094C



EVALUATE TILT AT 1.5
 LOCATION TRINIDAD CO/1325

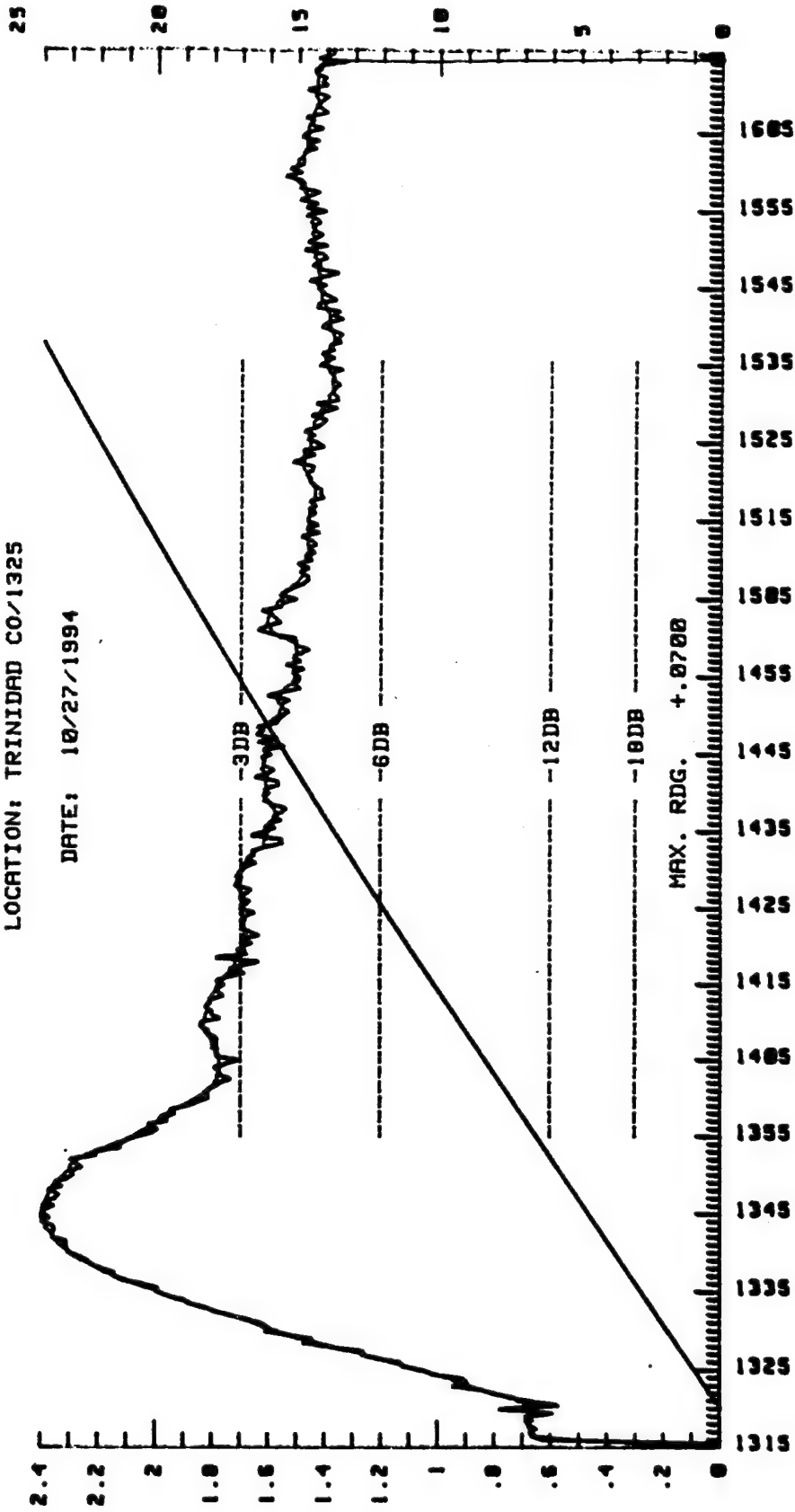
PRIMARY_RADAR

SYSTEM: 1.5

DATAFILE: S_TADI094C

LOCATION: TRINIDAD CO/1325

DATE: 10/27/1994



TIME (UNIVERSAL)

LONG. 104 0 51
LAT. 37 32 50

SUN ELEVATION ANGLE.

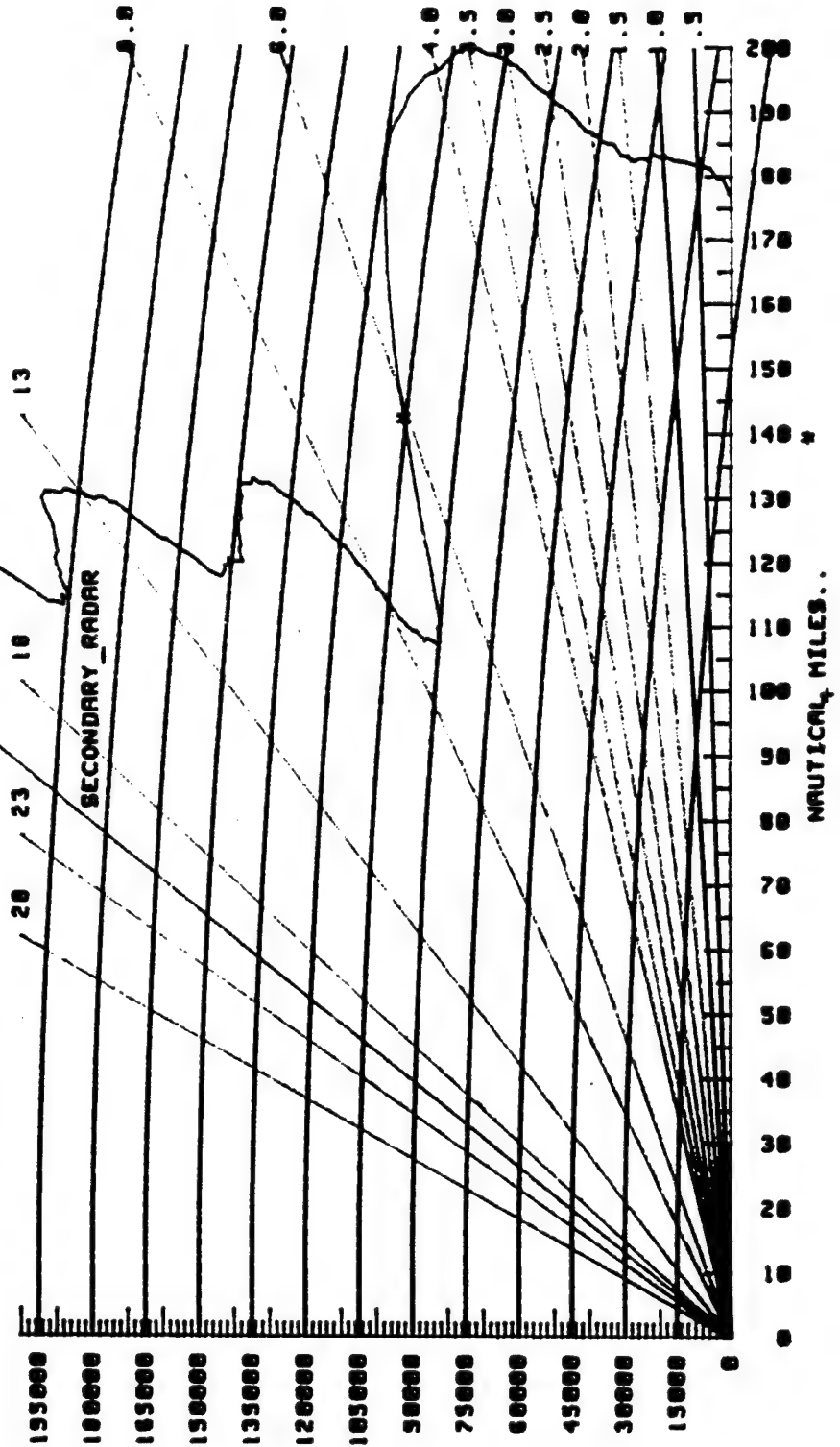
SOLAR INTENSITY

3810

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 3.45 Deg
3DB points are at 6.89 AND -1.48 Deg
6DB points are at 21.88 AND -2.61 Deg
3DB BANDWIDTH = 7.57 Deg

DATAFILE: S_TAD1894D

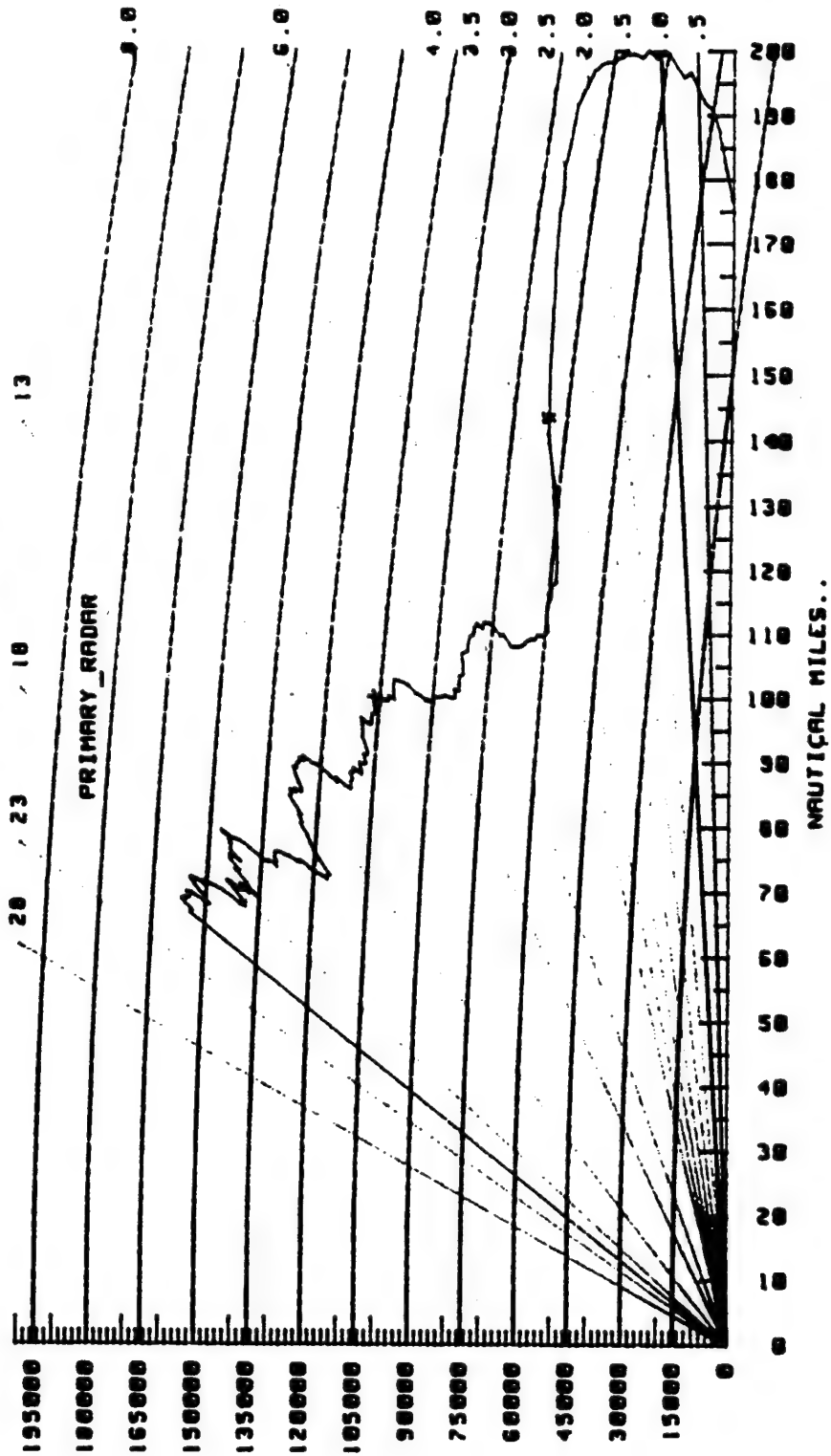


EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 1.14 Deg
 3DB points are at 3.36 AND -0.82 Deg
 6DB points are at 9.38 AND 9.21 Deg
 3DB BANDWIDTH = 4.18 Deg

DATAFILE: S_TAD1894D



EVALUATE TILT AT 1.5
 LOCATION TRINIDAD/1325

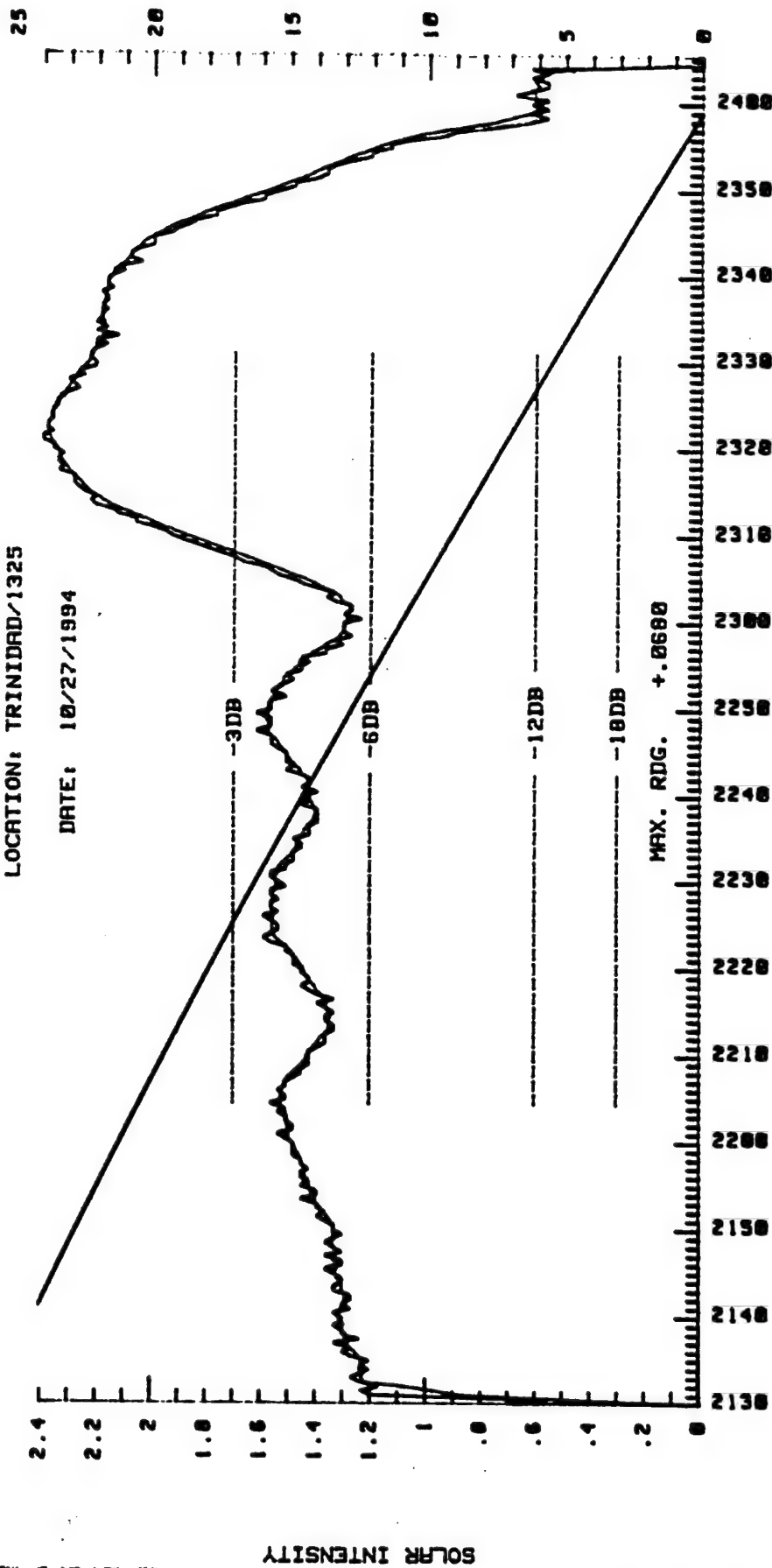
SECONDARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TADI094D

LOCATION: TRINIDAD/1325

DATE: 10/27/1994



DATAFILE: S_TAD10940

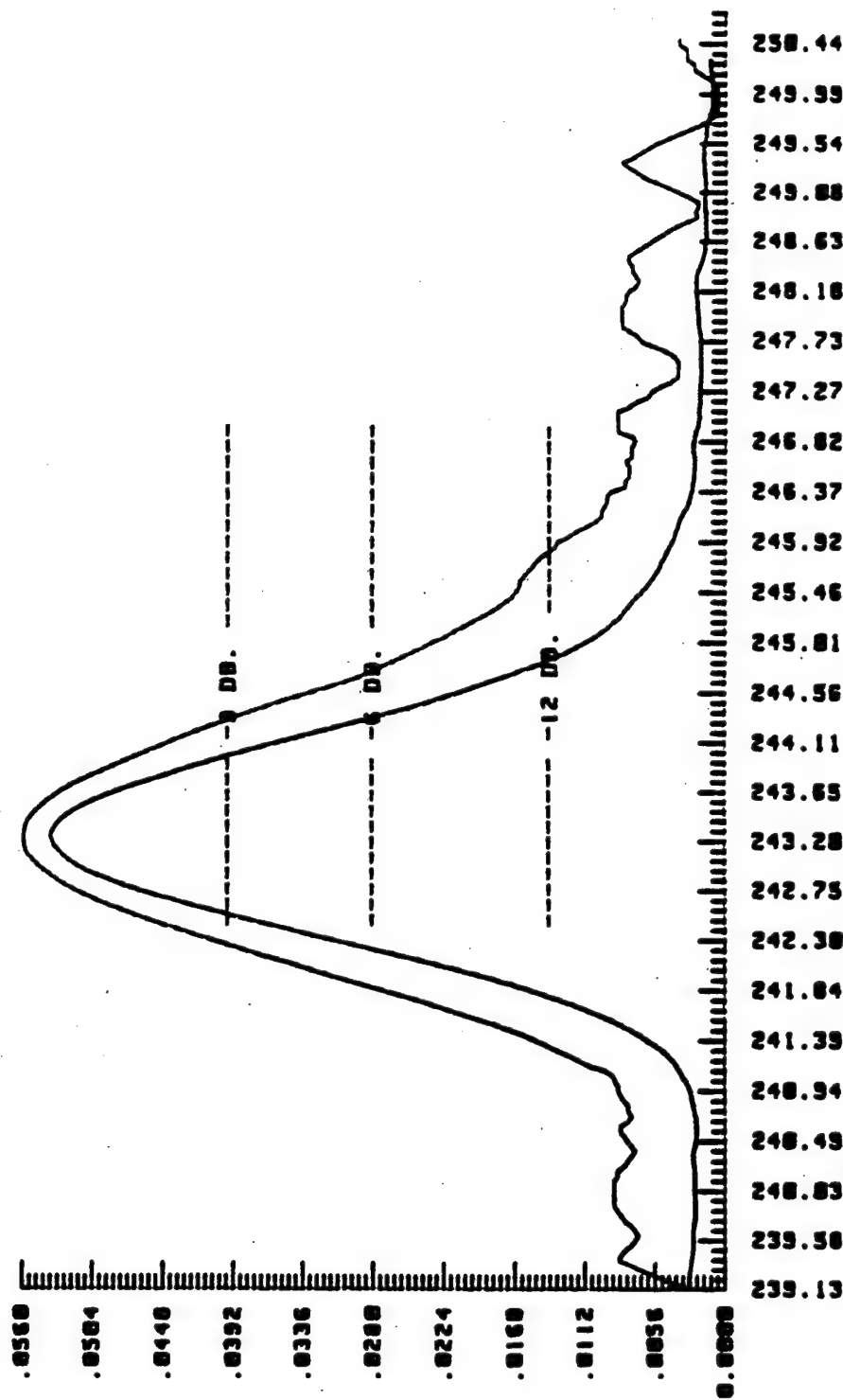
DATE: 10/27/1994

SYSTEM TYPE: ARSR2/1.3

SCAN PERIOD: 9.64 SEC.

AZIMUTHAL CUT

COMPUTED AZ 249.35



3 DB. B/W 2.08 DEG.

6 DB. B/W 2.90 DEG.

TRINIDAD/1325

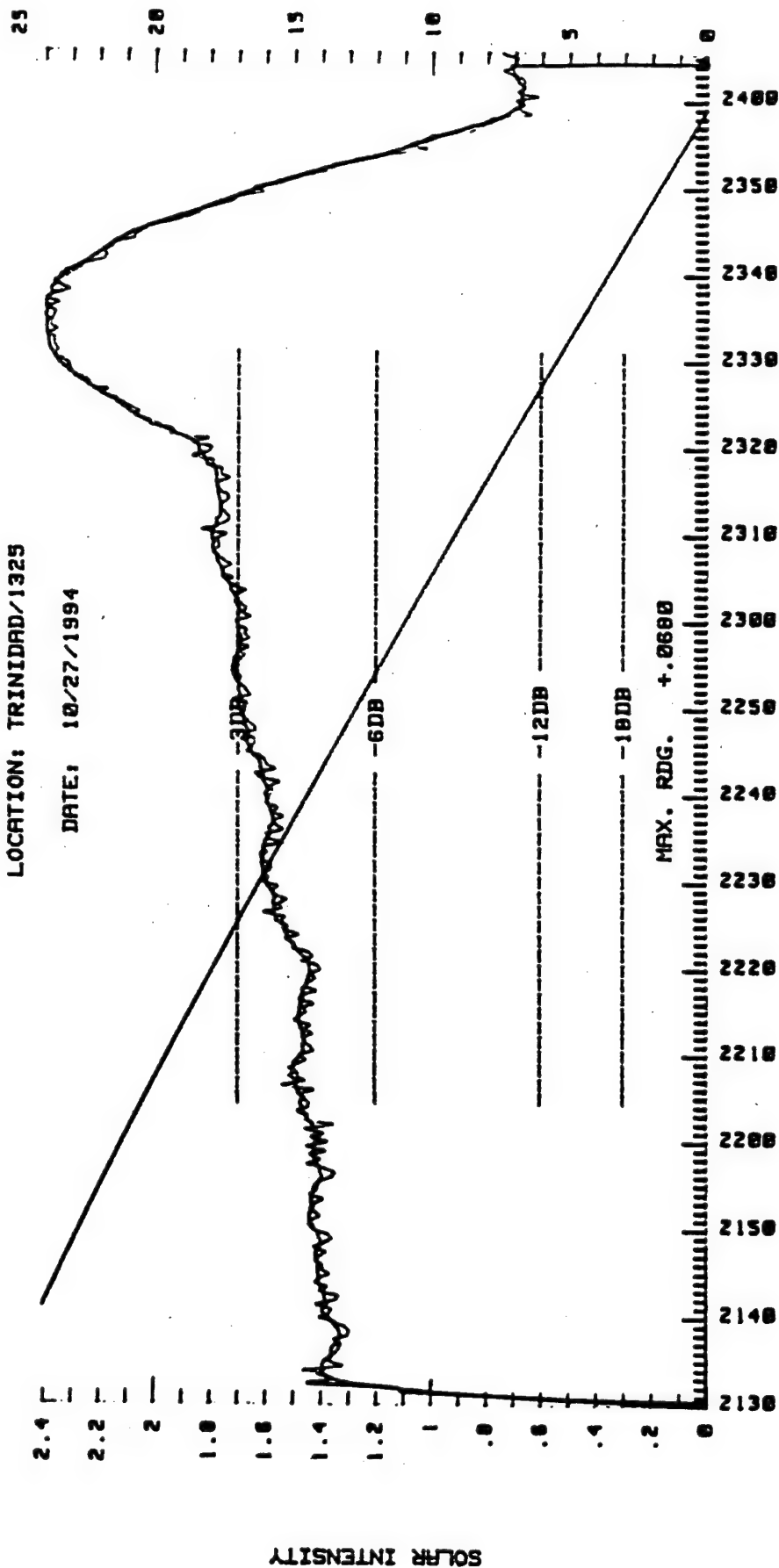
PRIMARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TADI094D

LOCATION: TRINIDAD/1325

DATE: 10/27/1994

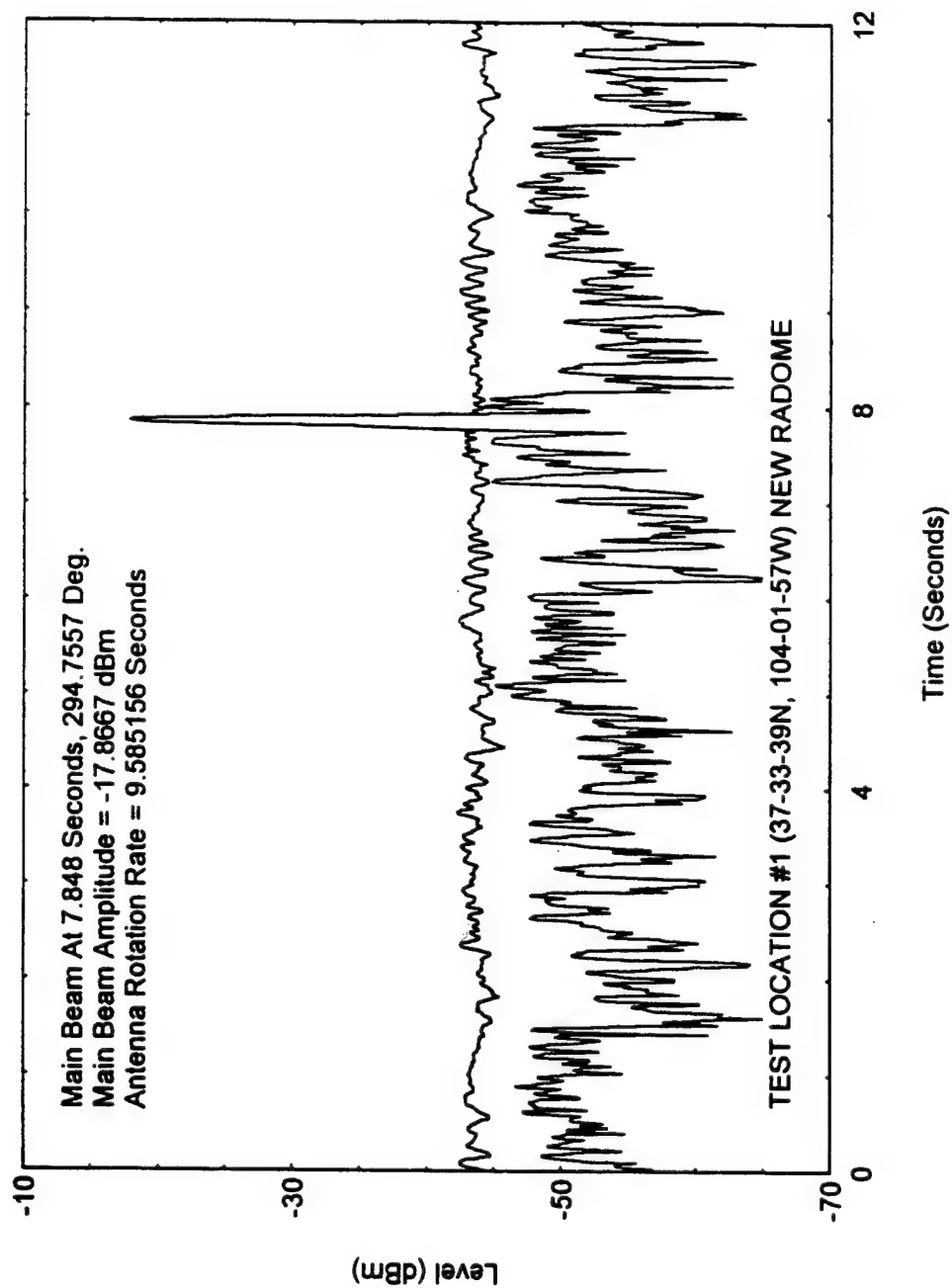


ATTACHMENT 3

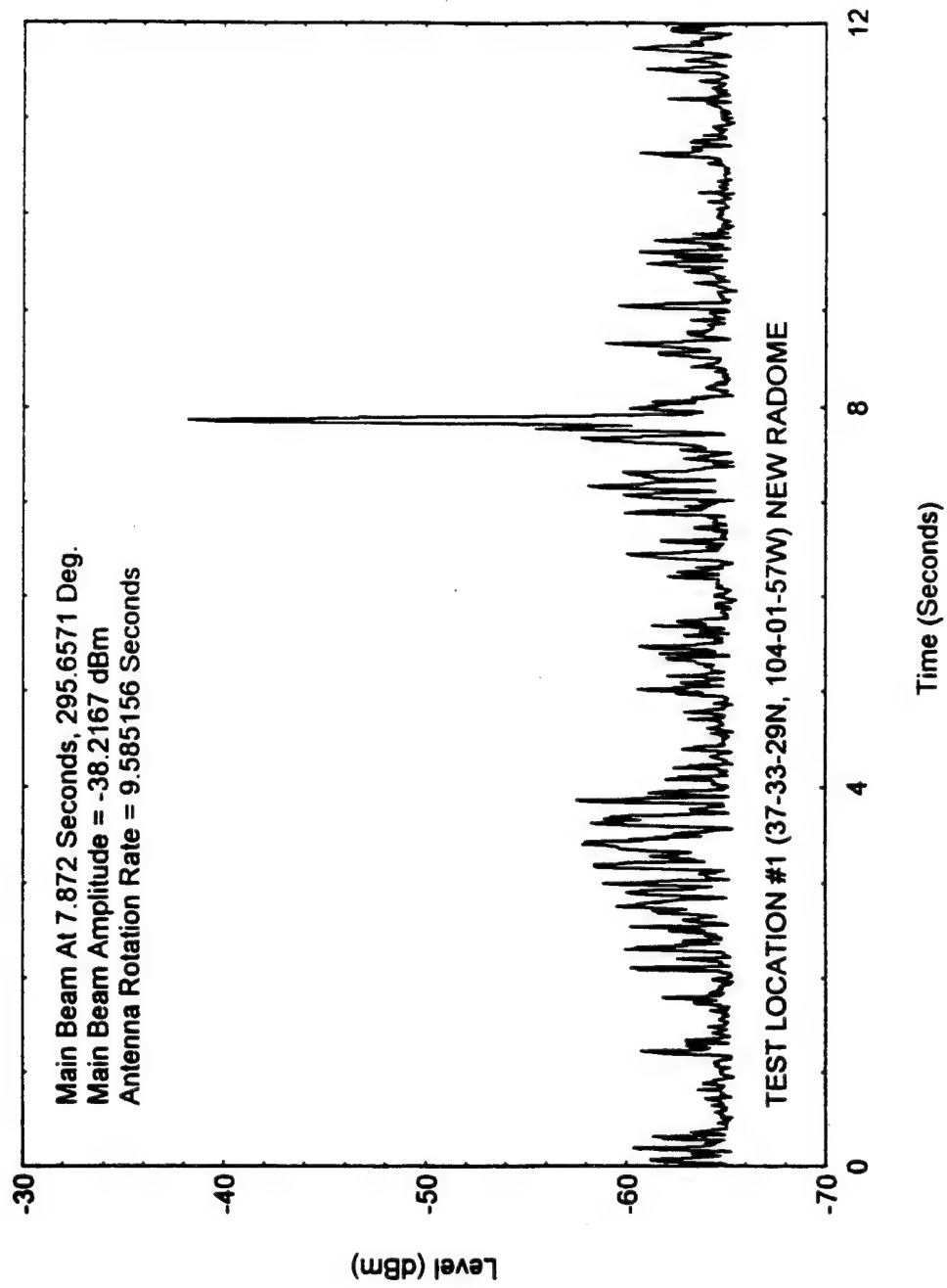
NEW RADOME

360° Horizontal Plots
Beam Width Plots
Vertical Plots (Solars)

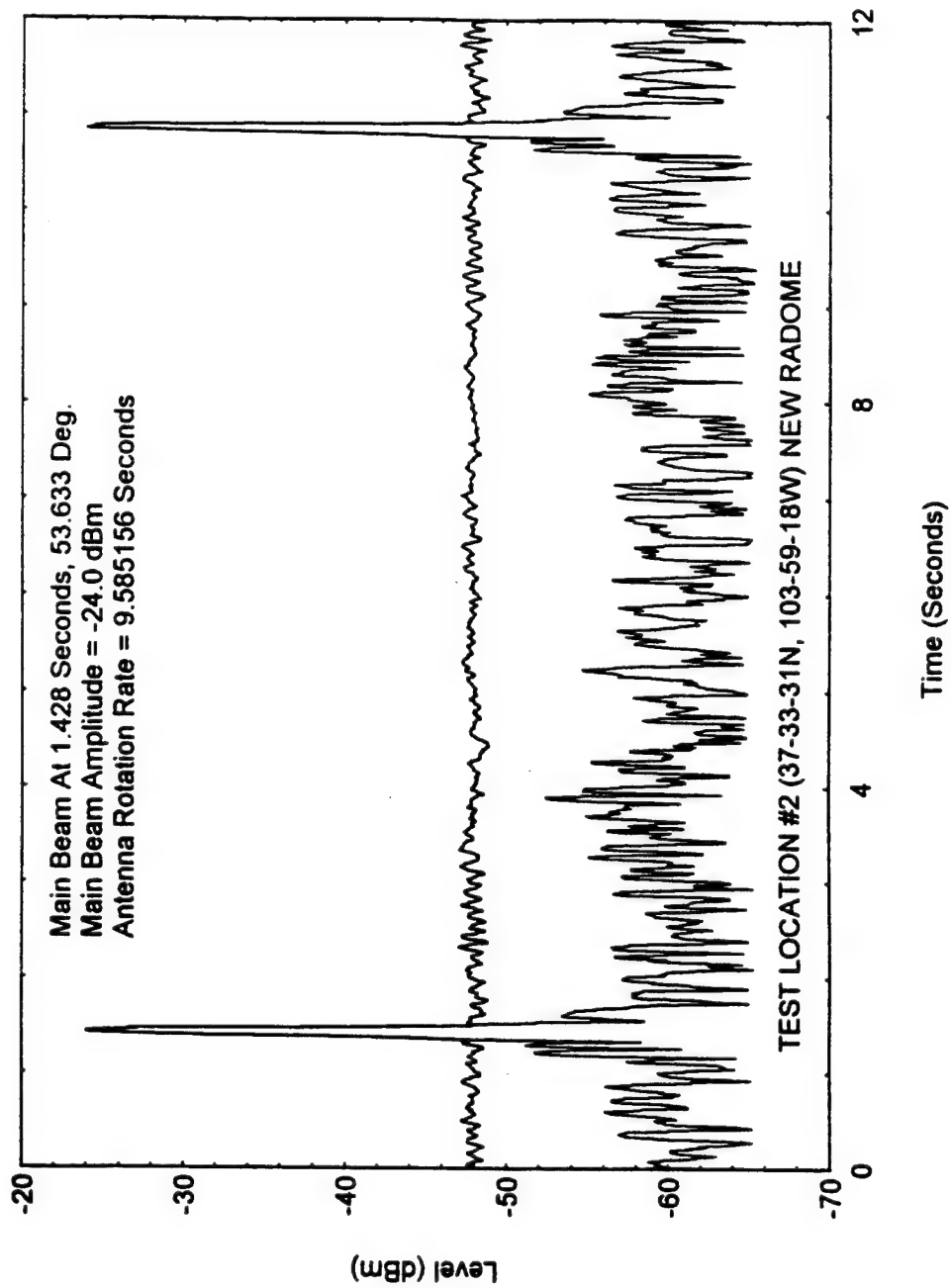
TRINIDAD, CO HORIZONTAL BEACON PLOT



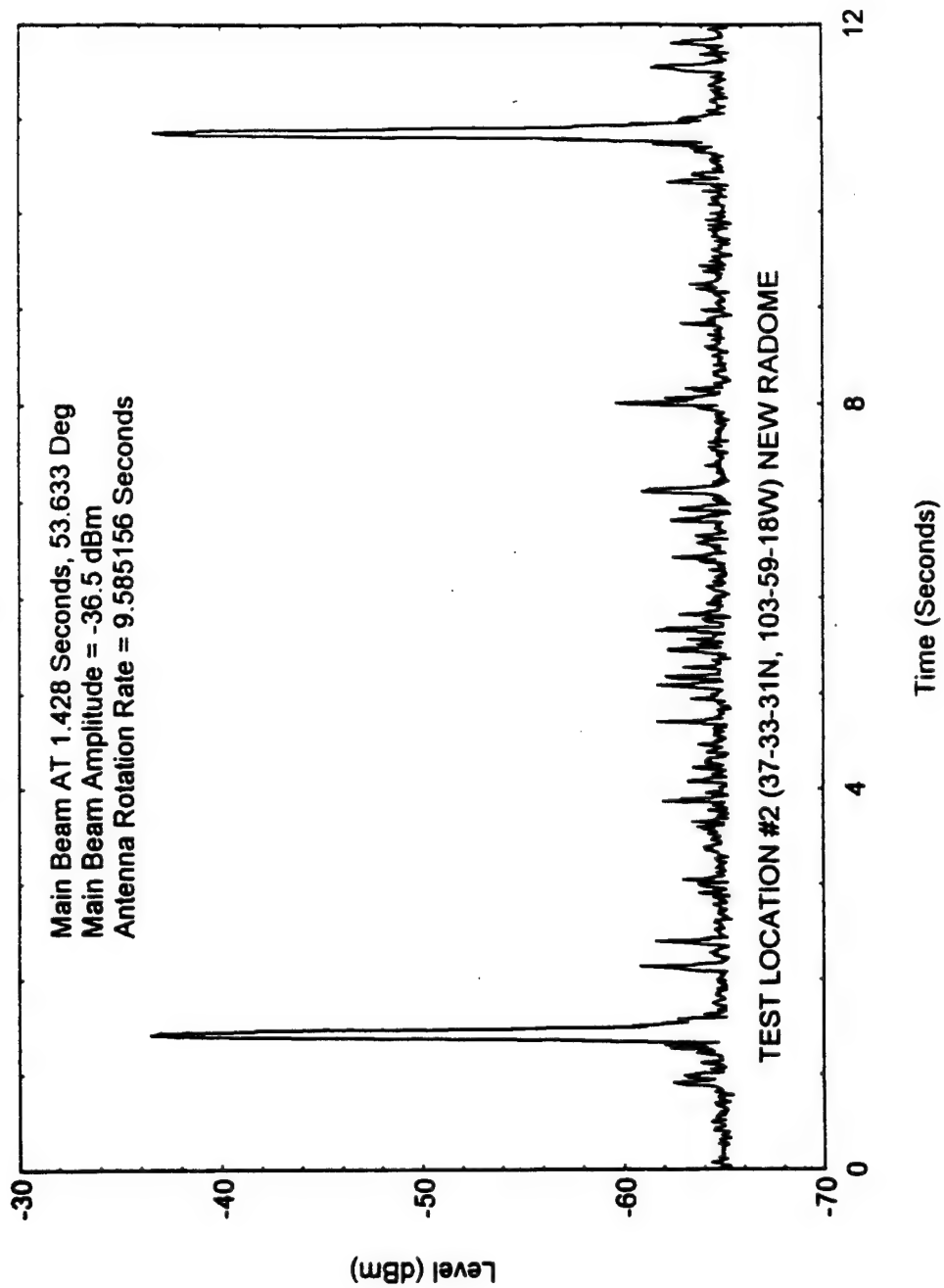
TRINIDAD, CO HORIZONTAL RADAR PLOT



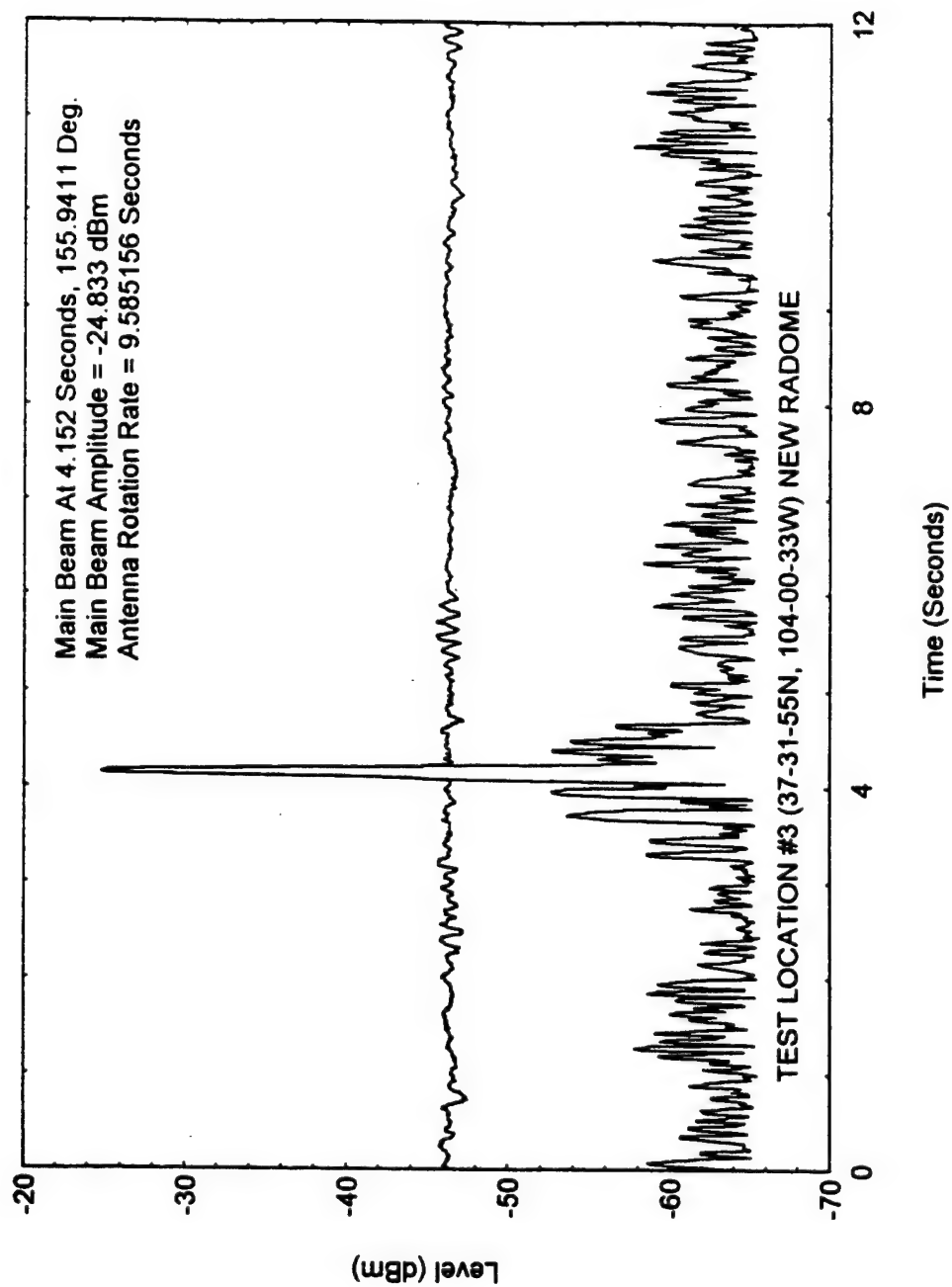
TRINIDAD, CO HORIZONTAL BEACON PLOT



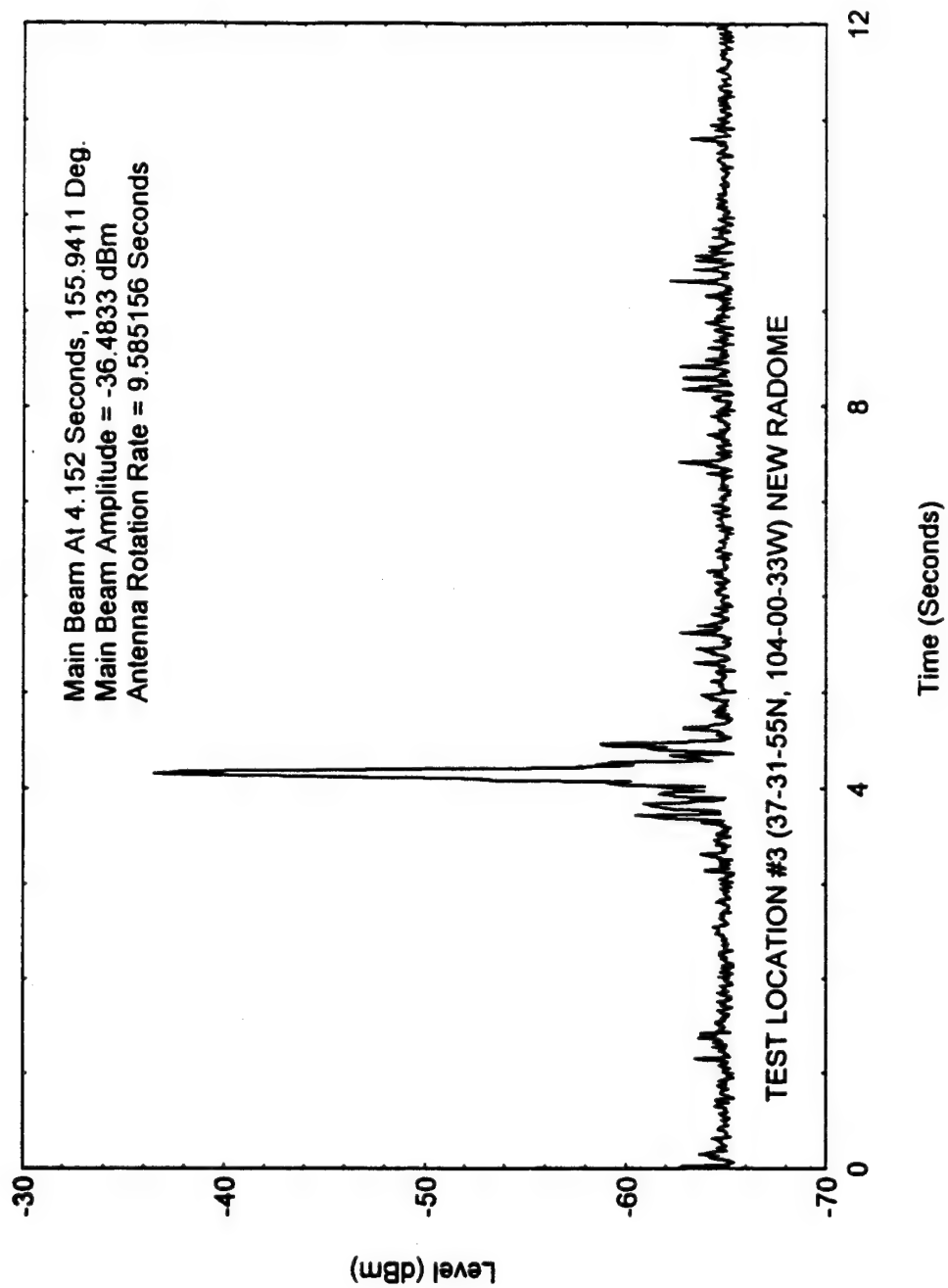
TRINIDAD, CO HORIZONTAL RADAR PLOT



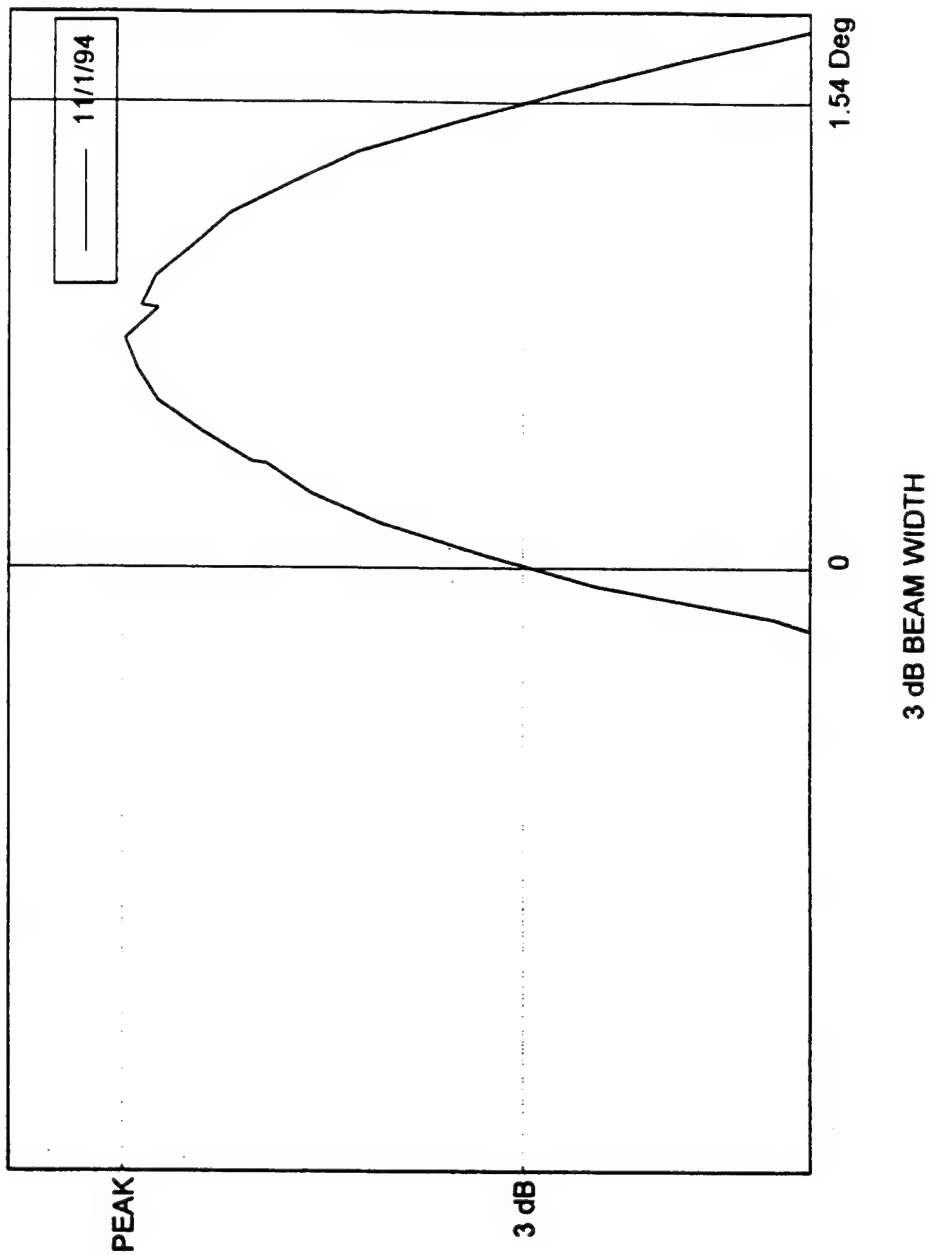
TRINIDAD, CO HORIZONTAL BEACON PLOT



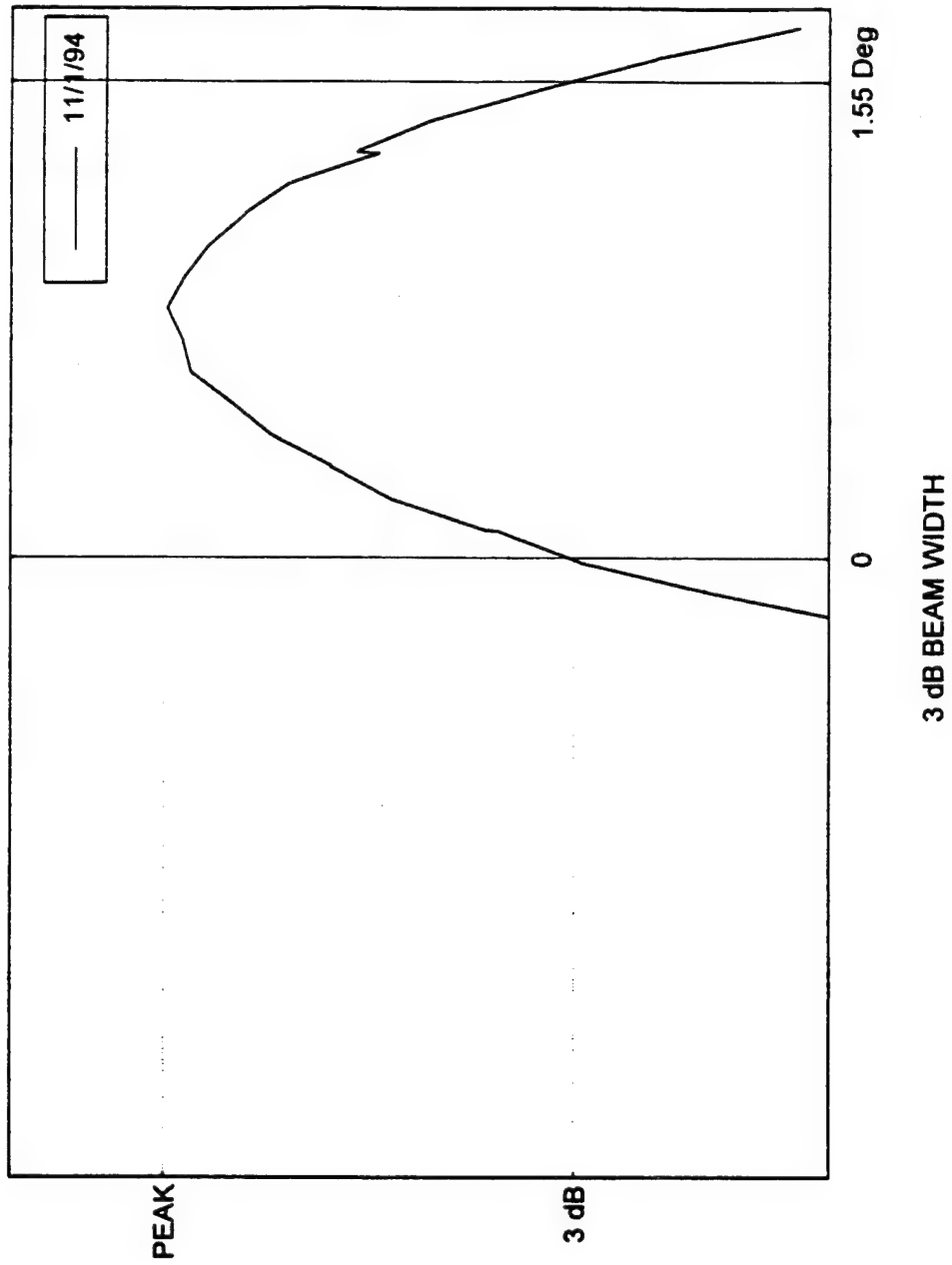
TRINIDAD, CO HORIZONTAL RADAR PLOT



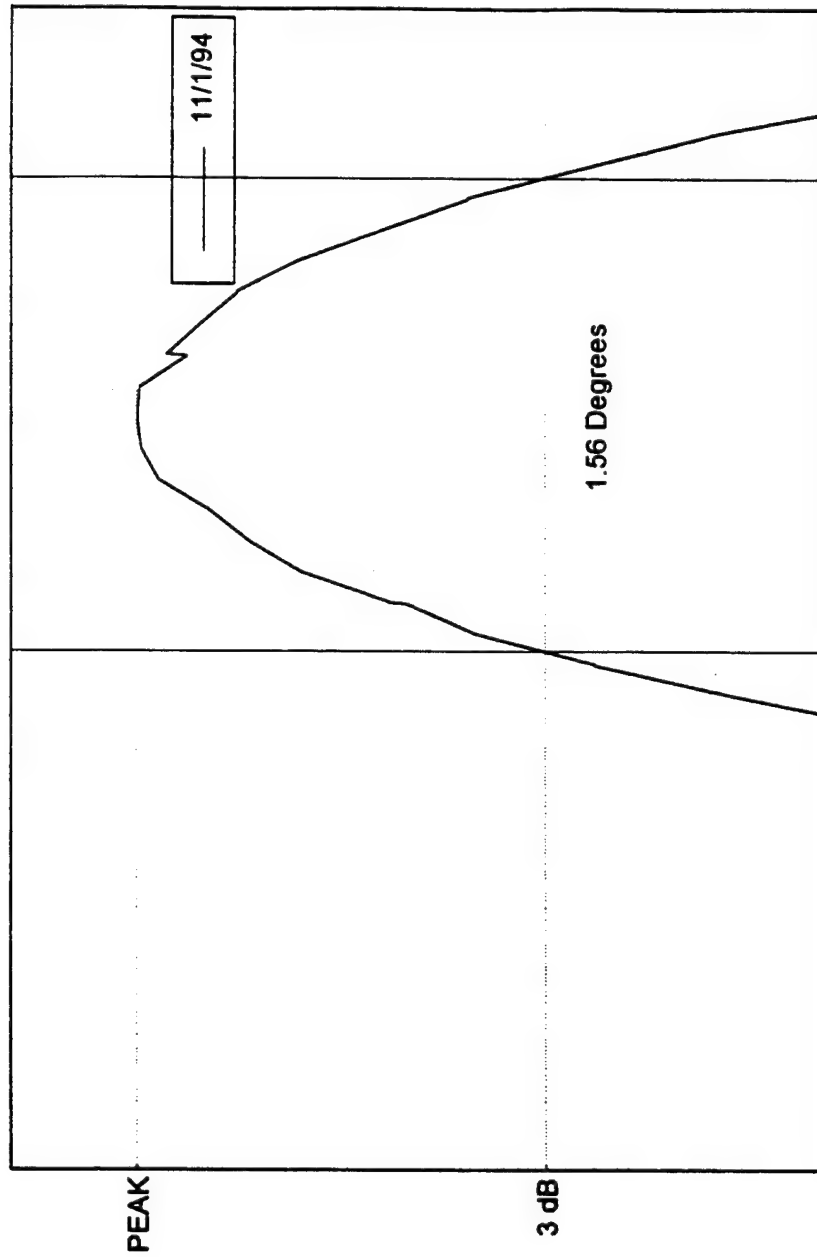
TRINIDAD CO TEST LOC#1, 1030 MHZ, BEAM WIDTH (NEW RADOME)



TRINIDAD CO TEST LOC#2, 1030 MHZ, BEAM WIDTH (NEW RADOME)



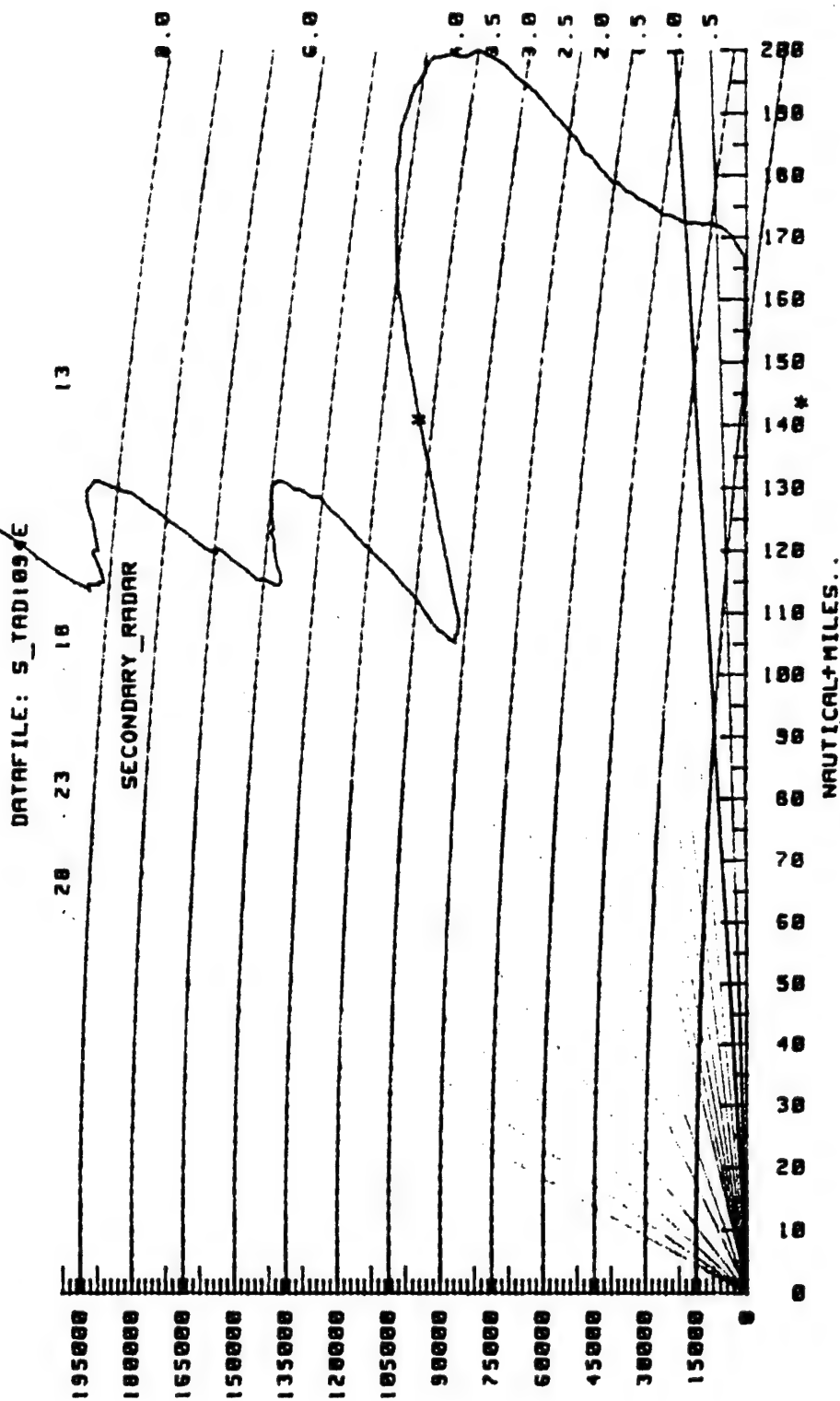
TRINIDAD CO TEST LOC#3, 1030 MHZ, BEAM WIDTH (NEW RADOME)



3 dB BEAM WIDTH

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 3.70 Deg
 308 points are at -1.06 AND 6.30 Deg
 608 points are at -2.27 AND 22.63 Deg
 308 BANDWIDTH = 7.43 Deg +



EVALUATE TILT AT 1.5
 LOCATION TAD ARSR/1325

7400

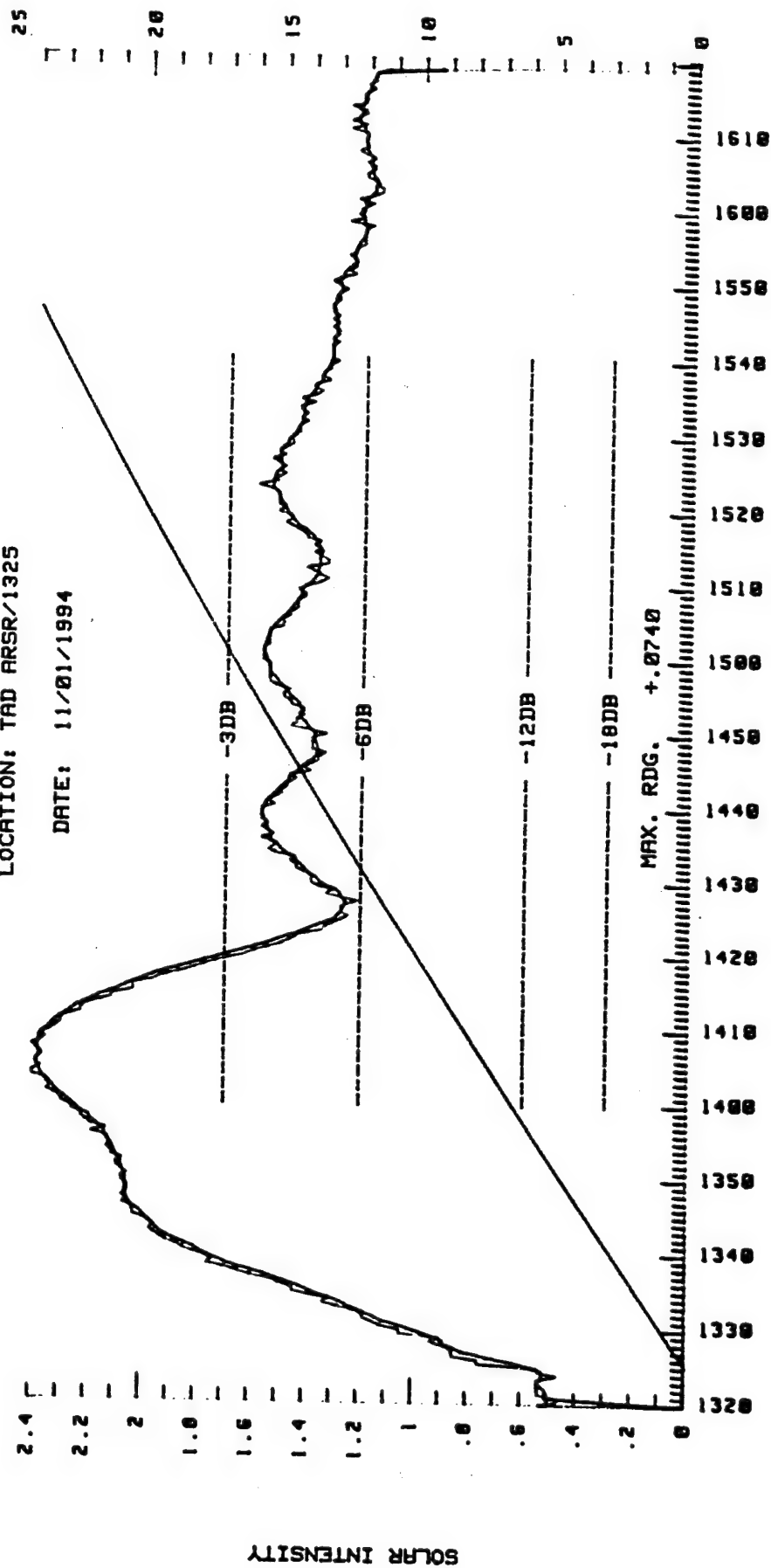
SECONDARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1094E

LOCATION: TAD ARSR/1325

DATE: 11/01/1994



DATAFILE: S_TAD1094E

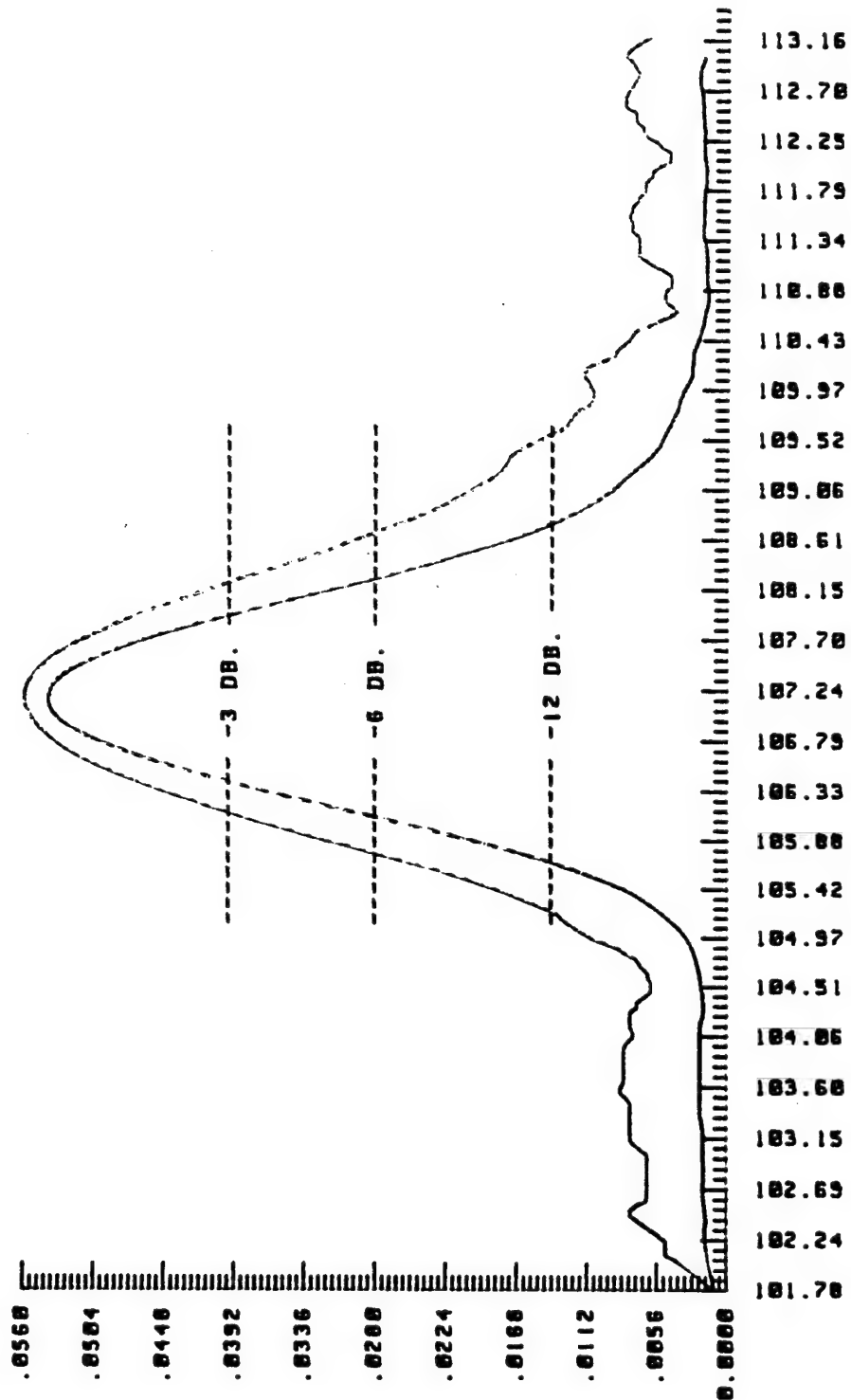
DATE: 11/01/1994

SYSTEM TYPE: ARSR2/1.5

SCAN PERIOD: 9.58 SEC.

AZIMUTHAL CUT

COMPUTED AZ 112.58



3 DB. B/W 2.09 DEG.

---- AZ. DEGREES.-----

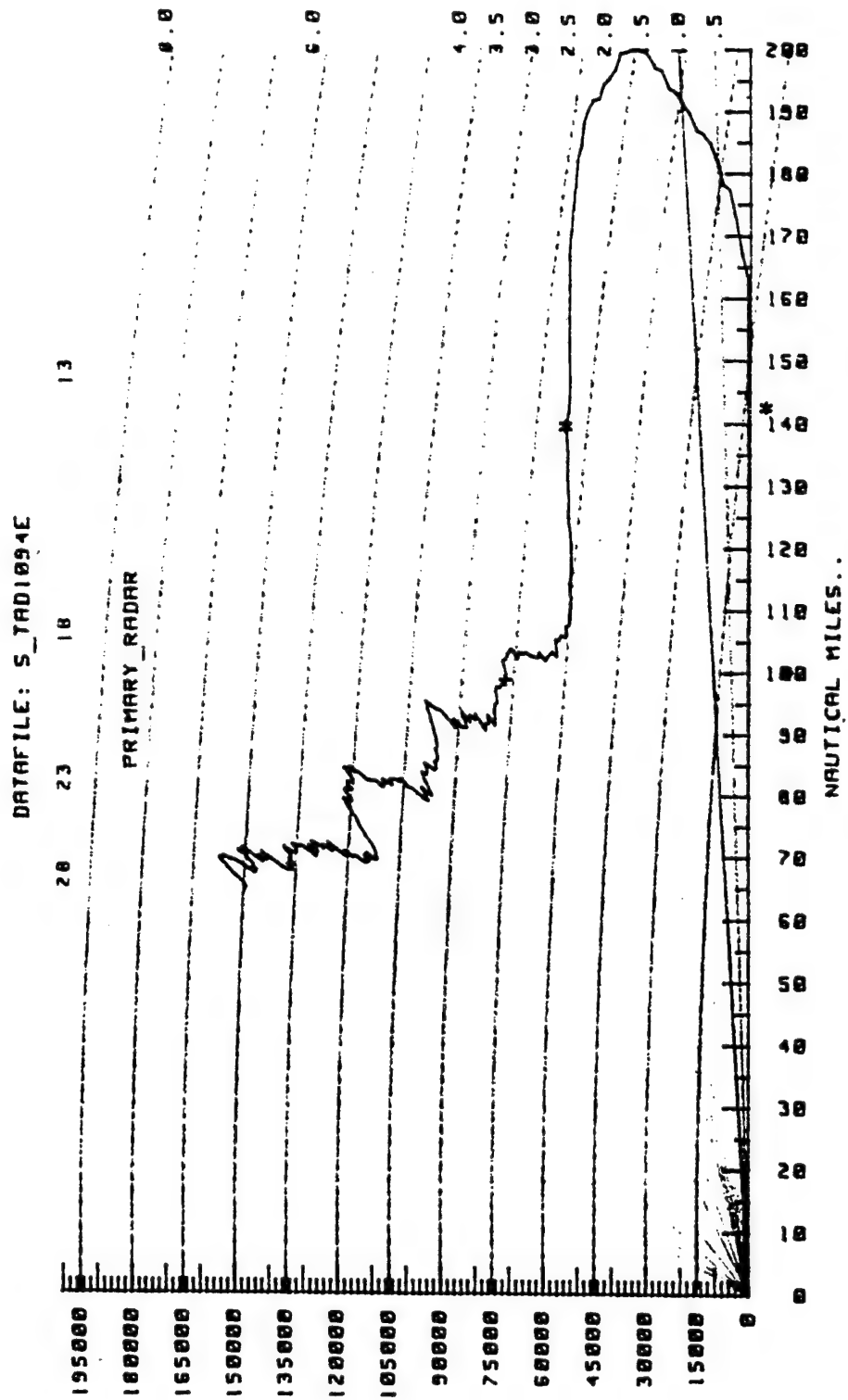
6 DB. B/W

2.91 DEG.

TAD ARSR/1325

DEG. ELEV.

ANTENNA ELECTRICAL TILT IS 1.62 Deg
308 points are at -1.31 AND 3.61 Deg
608 points are at -1.06 AND 6.73 Deg
308 BANDWIDTH = 3.93 Deg



EVALUATE TILT AT 1.5
LOCATION TAD ARSR/1325

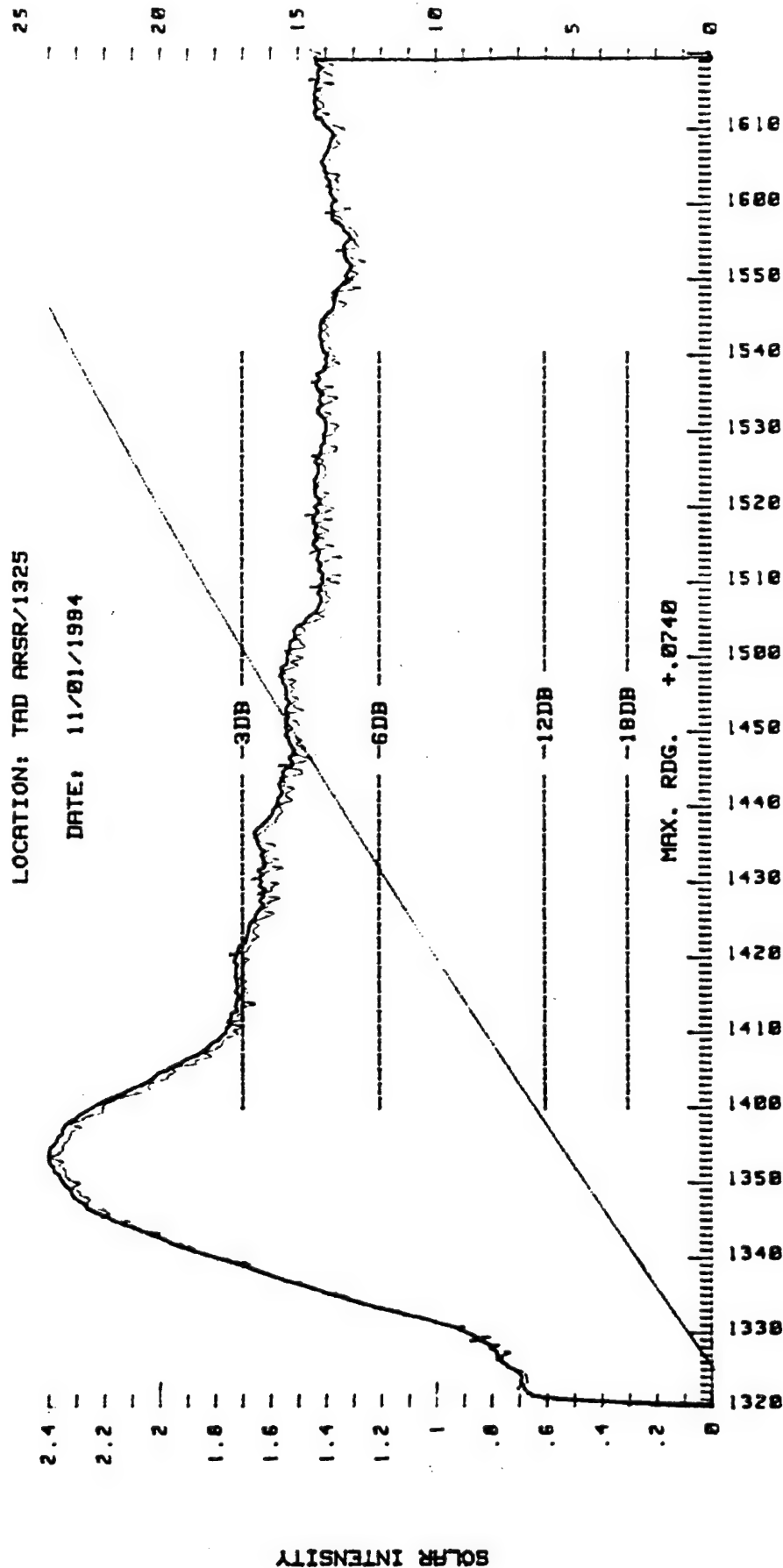
PRIMARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1094E

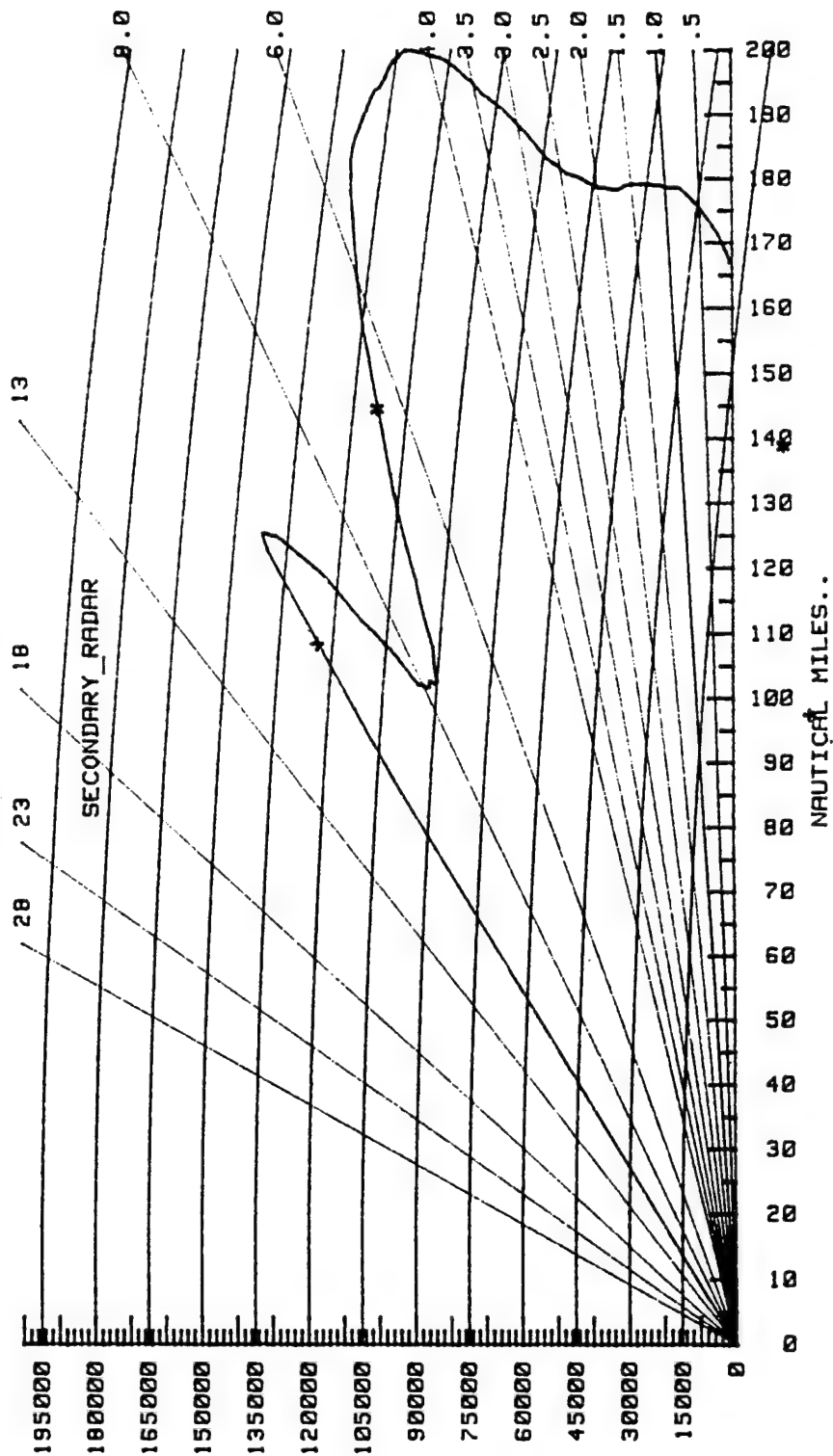
LOCATION: TAD ARSR/1325

DATE: 11/01/1984



ANTENNA ELECTRICAL TILT IS 4.22 Deg
 3DB points are at 6.45 AND -98 Deg
 6DB points are at 10.01 AND -2.10 Deg
 3DB BANDWIDTH = 7.43 Deg

DATAFILE: S_TAD1194F



EVALUATE TILT AT 1.5
 LOCATION TRINIDAD/1325

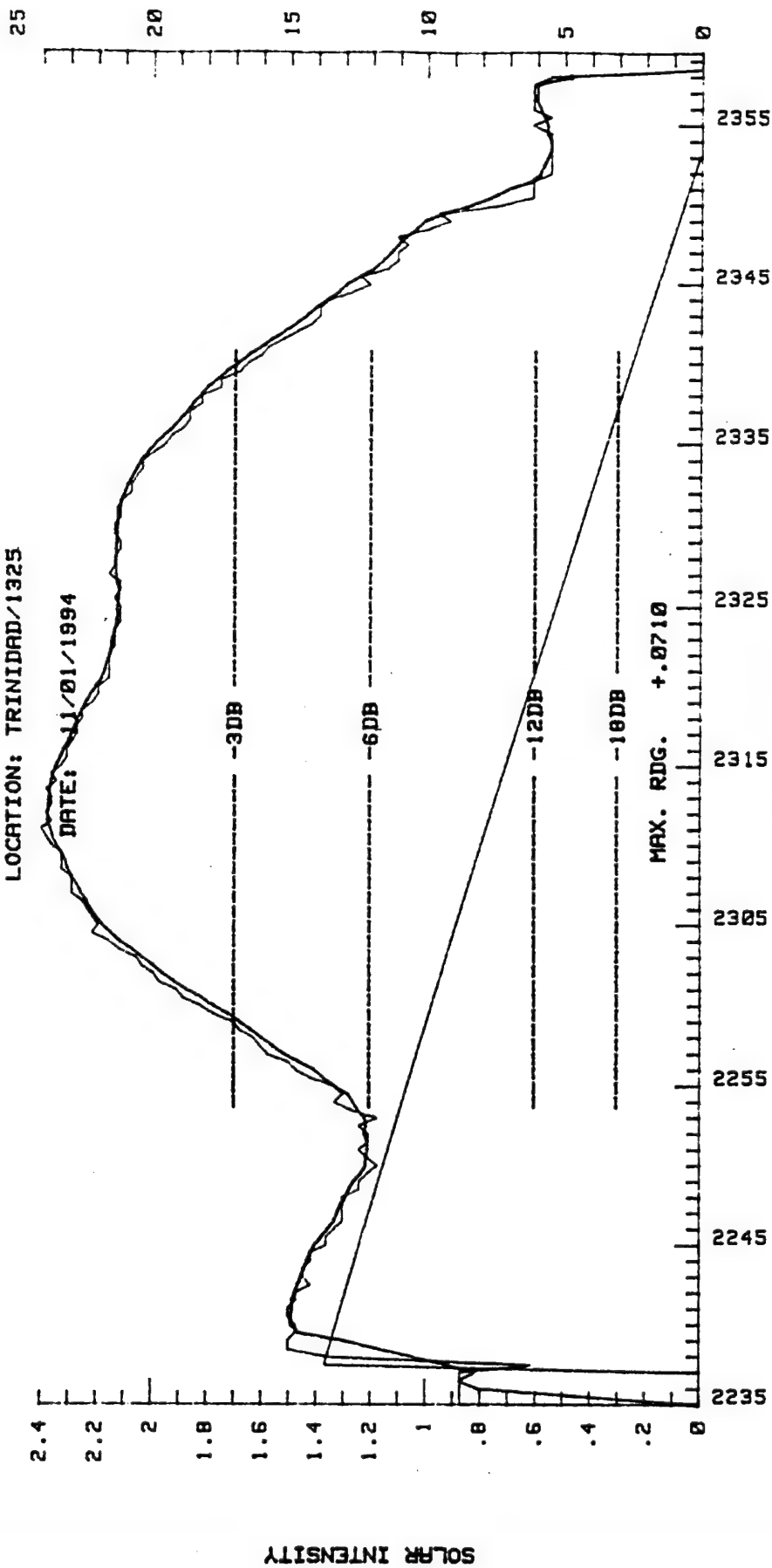
SECONDARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1194F

LOCATION: TRINIDAD/1325

DATE: 11/01/1994



DATAFILE: S_TAD1194F

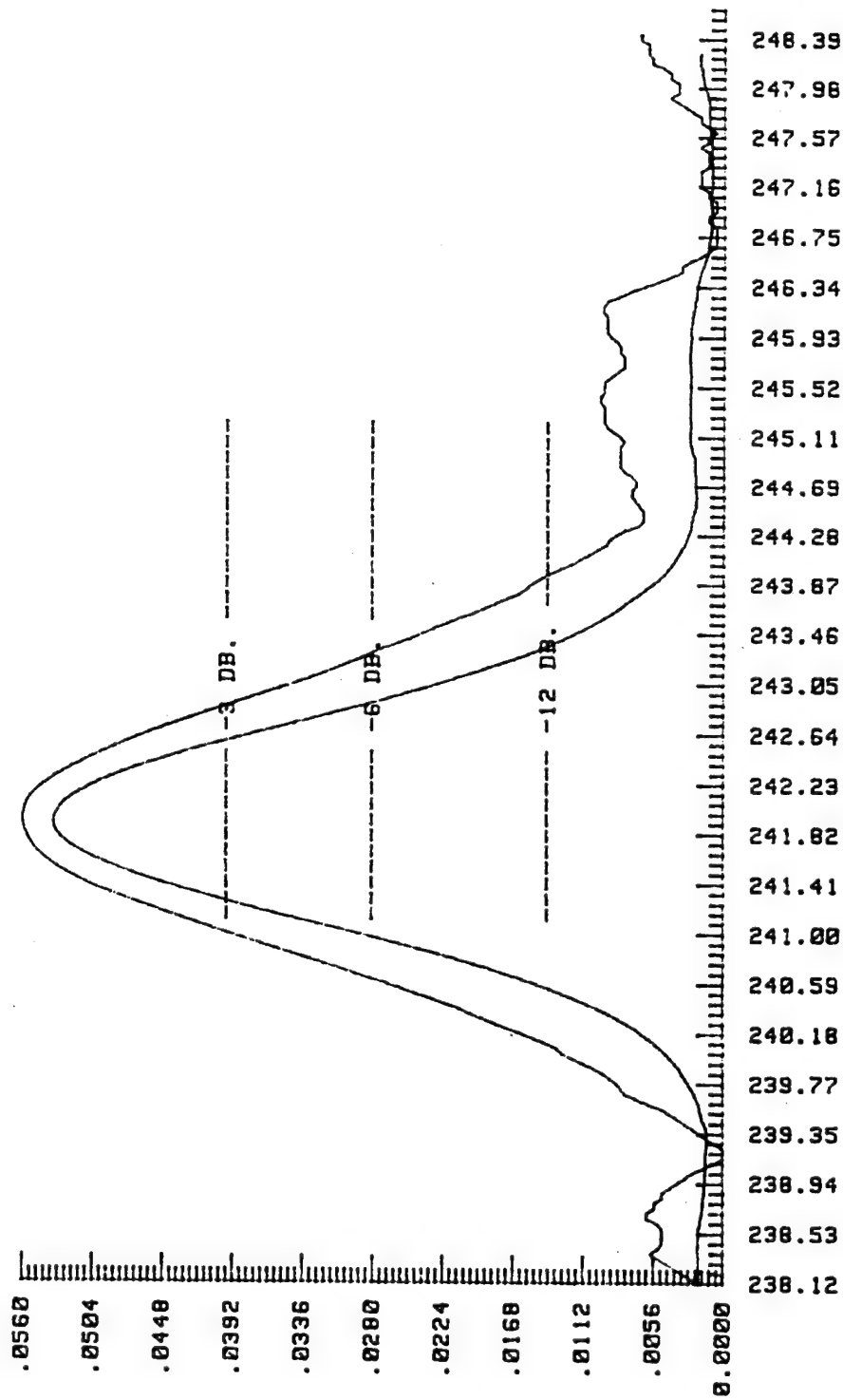
DATE: 11/01/1994

SYSTEM TYPE: ARSR2/1.5

SCAN PERIOD: 9.58 SEC.

AZIMUTHAL CUT

COMPUTED AZ 247.19



3 DB. B/W 1.85 DEG. ----- AZ. DEGREES..... 6 DB. B/W 2.71 DEG.

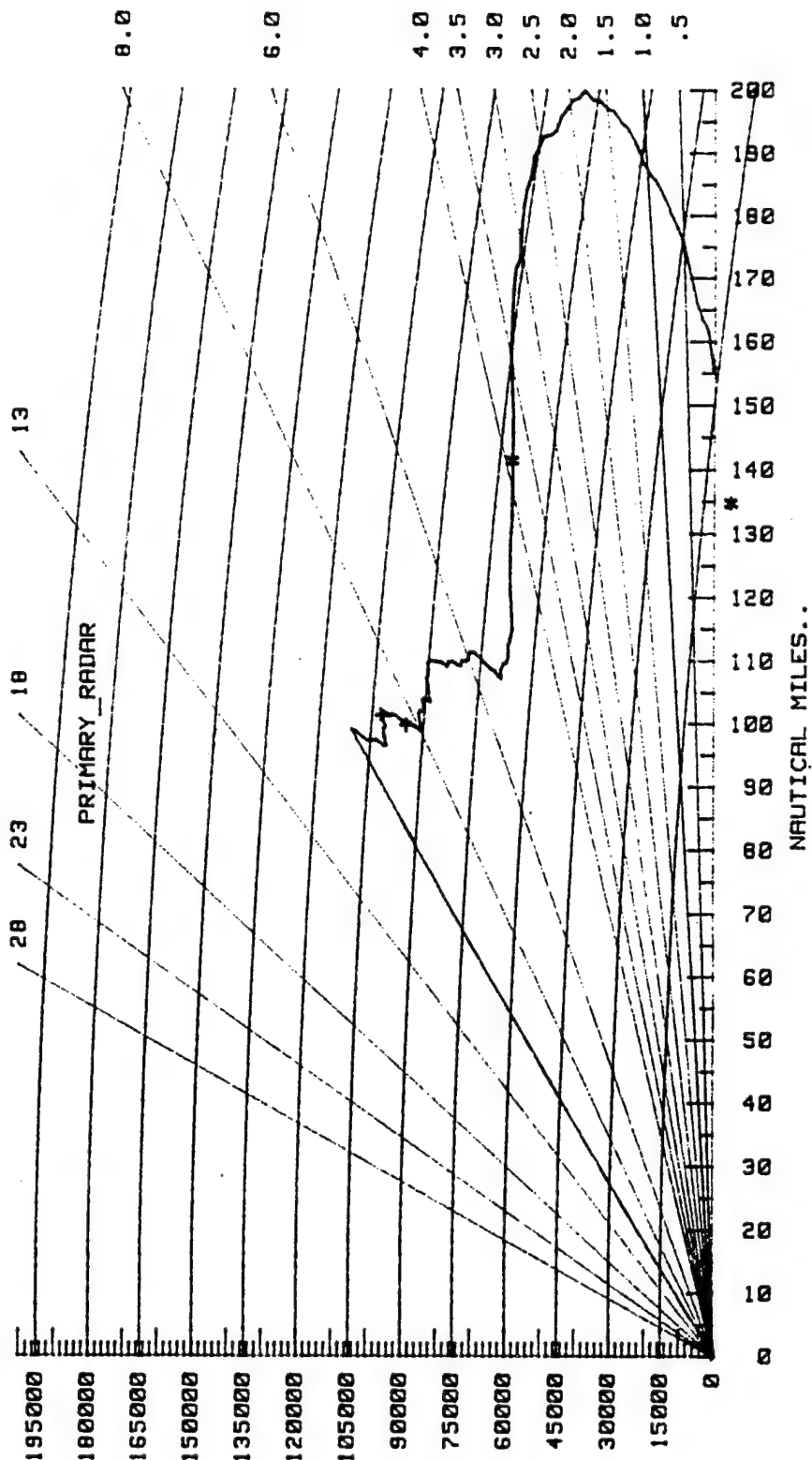
TRINIDAD/1325

DEG. ELEV.

ANTENNA ELECTRICAL YILT IS 1.78 Deg
3DB points are at 3.87 AND -.33 Deg
6DB points are at 8.81 AND 8.29 Deg
3DB BANDWIDTH = 4.20 Deg

DATAFILE: S_TAD1194F

PRIMARY RADAR



EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325

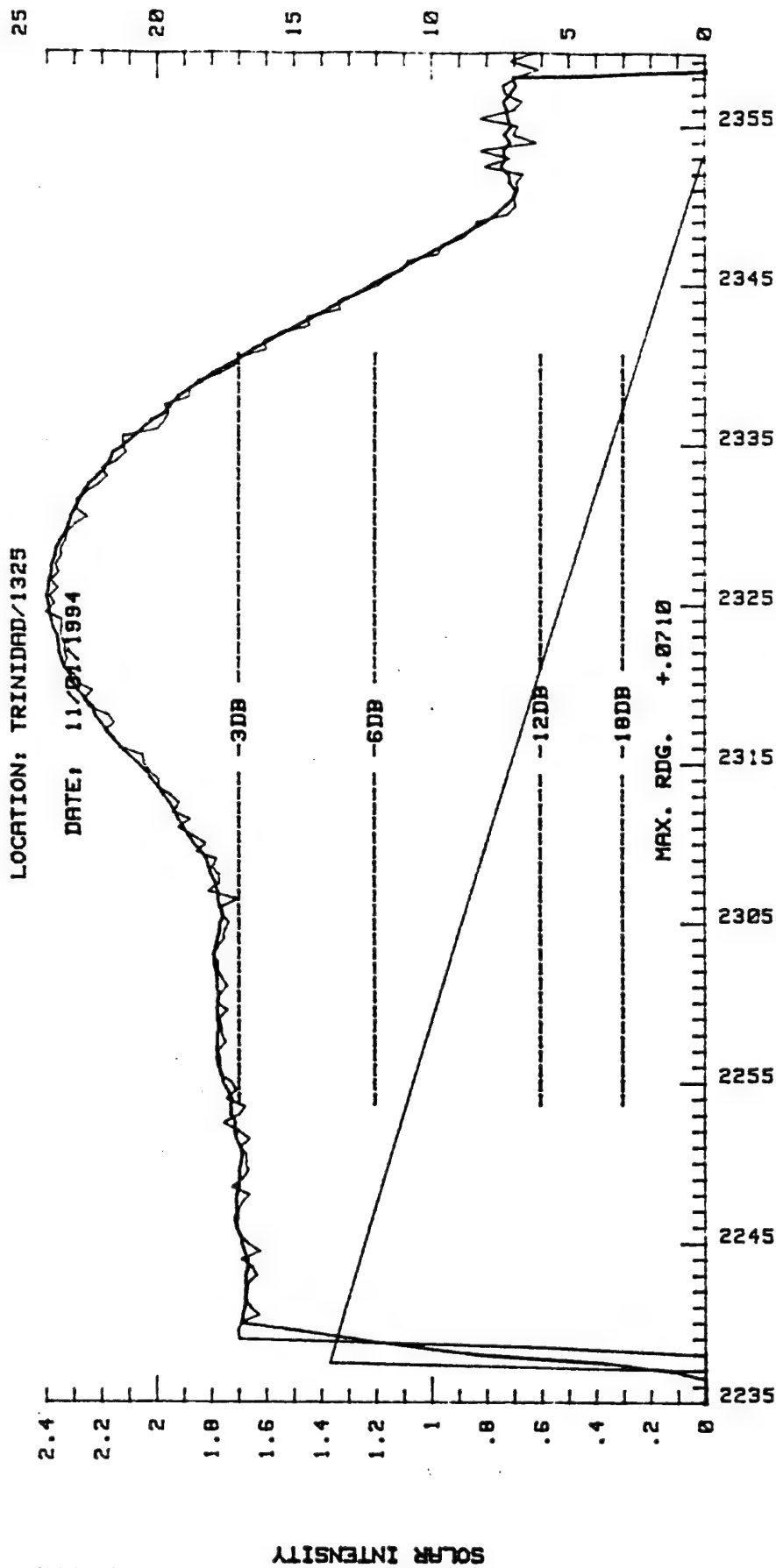
PRIMARY_RADAR

SYSTEM: ARSR2/1.5

DATAFILE: S_TAD1194F

LOCATION: TRINIDAD/1325

DATE: 11/01/1994



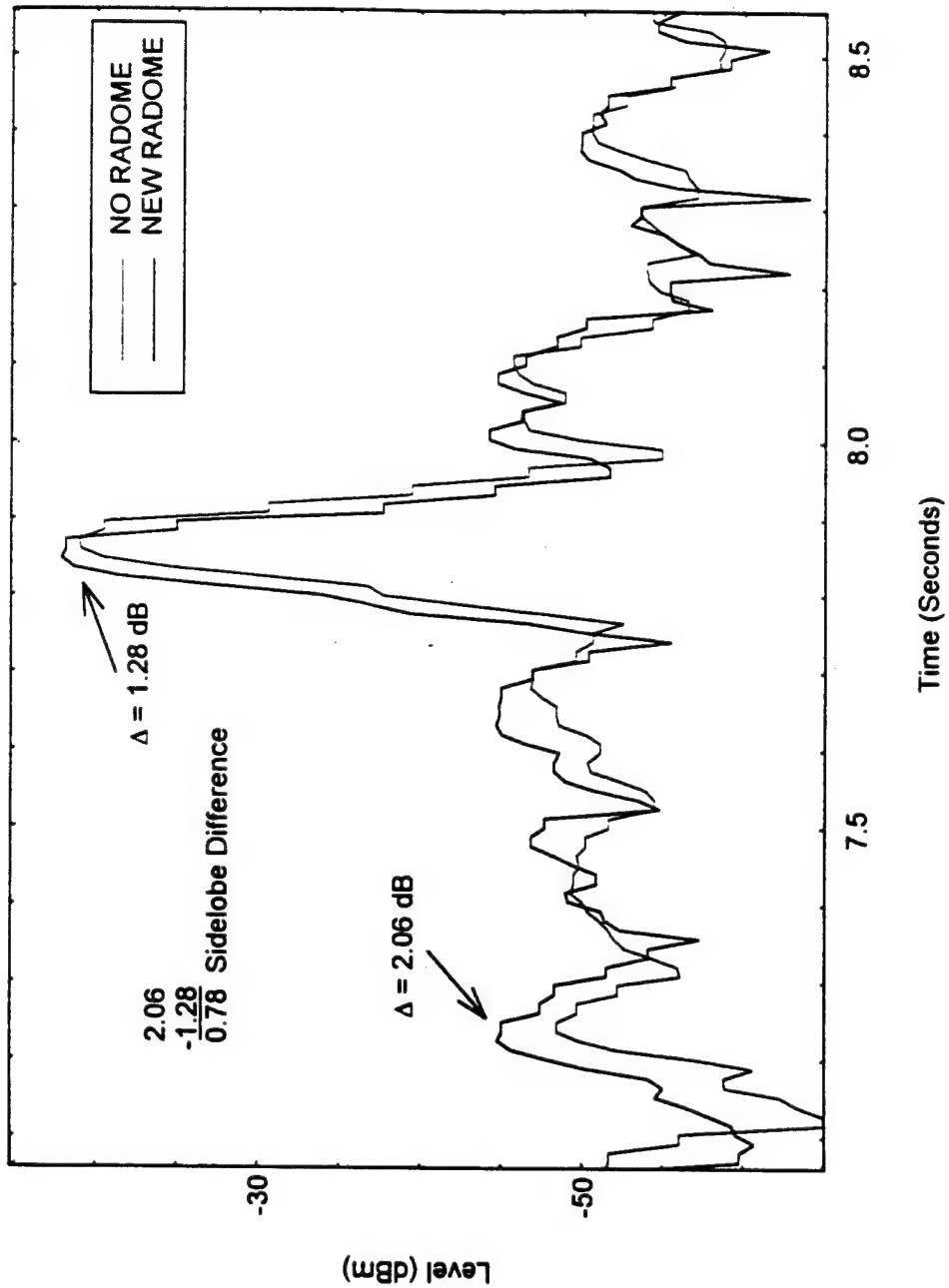
LONG. 104 0 51
LAT. 37 32 50

2240-6

ATTACHMENT 4

SIDELOBE DIFFERENCES

TRINIDAD, CO HORIZONTAL BEACON TYPICAL SIDELOBE DIFFERENCE



APPENDIX H

REPORT

VERTICAL RADIATION PATTERN MEASUREMENT TESTING

TRINIDAD EN ROUTE RADAR FACILITY (TAD)



U.S. Department
of Transportation

Memorandum

Federal Aviation Administration

Subject: Information: Radome Replacement Tests,
Trinidad, Colorado

Date: 3/29/95

From: Jim Ulm, ANM-464I

Reply to: Ulm
Attn of: X2324

To: Manager, ANM-464, Technical Support Section

The following is an update and amendment to the Trinidad, Colorado Radome Replacement Project testing, that occurred 11 October through 4 November 1994.

During the testing period, vertical radiation pattern measurements (solars) were performed with no radome in place and again with the new radome installed. The data was compared; however the typical differences between a morning and an evening solar and the differences between solars on successive days are greater than the limits specified by the program office. Therefore the only conclusion that we can make is that the new radome made no measurable difference in the vertical radiation pattern.



Jim Ulm
Spectrum Management Officer

APPENDIX I

REPORT

QARS DATA EVALUATION

DENVER ARTCC (ZDV) AFS



Memorandum

U. S. Department
of Transportation
Federal Aviation
Administration

DENVER (ARTCC) AIRWAY FACILITIES SECTOR
2211 - 17th Avenue
Longmont, Colorado 80501

Subject: INFORMATION: Evaluation of Radar
Data from Trinidad, CO, ARSR

Date: DEC 22 1994

From: Acting Manager, Denver (ARTCC) AFS

Reply to
Attn. of: Braslow:
303-651-4433

To: Manager, ACW-100

Installation of a new radome at the Trinidad, CO, long-range radar site was completed November 2. Following a successful flight check 2 weeks later, we began an in-depth analysis to determine whether the new structure had any significant or unusual effects on the radar site's operating performance.

In conducting our evaluation, we compared daily site performance parameters captured by the Quick Analysis of Radar Sites (QARS) program. Although we focused on parameters like Scans, Blip Scans, Search Reinforce, Azimuth Splits, Range Splits, Mode 3/A Validation and Reliability, Mode-C Validation and Reliability, we did consider QARS as a whole. We also relied on input from air traffic controllers and personnel at the Systems Maintenance Monitoring Console and at the site itself.

Based on our evaluation of data collected from October 9 through November 15, we concluded that the new radome had no distinguishable impact on the performance of the radar system at Trinidad. Meanwhile, data collected since our evaluation period confirms our conclusions. It should be noted that data collected during the installation period was not used in this analysis.

If you have any questions or comments concerning the information provided, please do not hesitate to contact Barry Braslow, Staff Engineer, Technical Support Office, at 303-651-4433.


John J. Humphries

APPENDIX J

REPORT

ELECTROMAGNETIC PERFORMANCE TESTING

ALBUQUERQUE ARTCC (ZAB) AFS



U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: **INFORMATION:** Trinidad (TAD) Long Range
Radar Radome Replacement Evaluation

Date: **DEC 08 1994**

From: Acting Manager, Albuquerque ARTCC AFS

Reply to
Attn of:

To: Associate Program Manager for Test, ACW-100B

As part of the Mode S project, the radome at Trinidad (TAD) radar was replaced. The national office requested that Albuquerque ARTCC (ZAB) compare TAD radar performance before and after the radome replacement to verify that there is no adverse impact to air traffic control. The comparison revealed some small differences, but nothing that should impact air traffic control. The following is a detailed summary of the comparison:

RARRE program runs were done for data collected on October 14, 1994, at 19:00z to 24:00z (before the radome was removed) and on November 25, 1994, at 20:00z to 24:00z (after the radome was installed). The radar was operating on the same radar and beacon channels at those times.

Overall, radar reinforcement was 64 percent before and 62 percent after the radome replacement. The difference was mostly in the 50 to 105 mile range. The radar reinforcement before the replacement was around 70 percent and afterwards was around 60 percent. At other ranges, the radar reinforcement was slightly better afterwards than before. It is possible that these small differences are due primarily to differences in traffic patterns at the time of the data recordings.

On the Altitude and Range plots, the radar coverage after the replacement was 1,000 to 2,000 feet worse (higher) than before replacement. The greatest difference was at long range.

The range of radar coverage was 187 nautical miles before the replacement and 185 miles after. This range is less than normal, a coverage of 200 nautical miles is more typical.

BFTA program runs were done on data recorded October 14, 1994, and November 3, 1994. On these dates, the radar was operating on the same beacon channels. Recordings before the radome replacement show 45 false targets in 177834 beacon returns for a rate of .025 percent. Recordings after the replacement show 35 false targets on 143408 beacon returns for a rate of .024 percent. These rates are extremely good. The composition of the splits was roughly similar except that there were fewer ring around splits on data recorded after the radome replacement.

A small amount of PRF interference is indicated 80 degrees from the site. The altitude of the false targets, around 29,000 feet and higher, indicate that the range of the interfering radar is perhaps 370 nautical miles from the radar. The false target rate due to these false targets is very low, and it occurred with equal frequency both before and after the radome replacement.

COMDIG program runs showed that the radar was performing at least as well after the radome replacement. There was a definite improvement in parrot azimuth deviation. The parrots were outside the 2 acp limit about 9 percent of the time on the data collected before the radome was replaced. On recordings done after the radome was replaced, only one parrot return in 1,500 was outside the 2 acp limit. It isn't clear if the radome is the cause of this, but it is a great improvement.

In conclusion, there were some small changes in radar performance when radar data collected before the radome replacement is compared to data collected afterwards. These changes are small and should not affect air traffic control. Some of the changes indicate improvement in radar performance.

If you should require additional information, please contact David Roop, Technical Support Staff, at (505) 856-4451.


For Joseph R. McGuire, Jr.

APPENDIX K

REPORT

ATCS QUESTIONNAIRE

DENVER ARTCC (ZDV)



U.S. Department
of Transportation
Federal Aviation
Administration

REC'D ANM-500/501

JAN 9 1995

Memorandum

ACTION:

INFO:

DENVER AIR ROUTE TRAFFIC CONTROL CENTER

2211 - 17th Avenue

Longmont, Colorado 80501

Subject: INFORMATION: Trinidad Radar Questionnaire

Date: JAN 05 1995

Reply to
Attn of:

From: Air Traffic Manager, ZDV-1

To: Manager, Air Traffic Division, ANM-500

On November 17, 1994, the Trinidad radar questionnaire was distributed to the control room. Controller participation with this survey was voluntary. As of this date, no questionnaires have been completed and returned to us.

Airspace and Procedures specialists have conducted several discussion sessions with controllers in an attempt to assist in the data-gathering process. Basically, the radome replacement has been transparent. There has not been a reported increase in the incidence of ring-around, false targets, or code swaps.

In discussions with controllers about the questionnaire, most found the questionnaire too technical and too long. Some of the language used in the questionnaire is more pertinent to a radar technician than an en route controller.

If you have any questions concerning this subject or if we can be of any further assistance, please contact David Laschinger, Assistant Manager-Airspace & Procedures, at (303) 651-4205.

Donald R. Smith

APPENDIX L

REPORT

FLIGHT CHECK

TRINIDAD EN ROUTE RADAR FACILITY (TAD)

FLIGHT CHECK REPORT

Trinidad, Colorado

ARSR-2, ATCBI-3

PURPOSE

This report will provide a summary of the flight check conducted on the ARSR-2 and ATCBI-3 radar systems at the Trinidad Long Range Radar Site (LRR). The objective of the flight check was to verify that the structural members of the newly installed radome do not attenuate, or cause reflections, false target positions or ring-around of the beacon or radar signal.

This was not a commissioning flight check but a *special inspection* as described in paragraphs 215.3D (1) and (3) of the Flight Check Manual OA P 8200.1. The Trinidad radar/beacon systems were out of service during the radome installation, but not decertified.

The flight check to verify the new radome included an inbound aircraft flying at 15,600 feet MSL with an orbit around the radar site at 10 nautical mile radius and an altitude of 8,000 feet MSL. Previous flight check data from the Trinidad LRR was not available, so no comparison between the radar performance with the old radome and the new radome is possible.

The flight check was conducted on November 15, 1994. This report contains a written explanation of the flight check procedures, recorded data supporting the analysis, and a summary of the coverage observed.

ANALYSIS TOOLS

During the flight check three methods were used to collect information for later analysis. QARS data was recorded at the Denver Air Route Traffic Control Center (ARTCC) and analyzed by personnel at that location familiar with the software. Manual scoring was used to record the inclusion or absence of a radar or beacon target as displayed on the controller's display. Raw data was recorded by personnel at the Trinidad radar site using digitized output from the Common Digitizer (CD). The conclusions in this report were based on analysis of the manual scoring and CD data.

Manual scoring was performed by observing the presence or absence of a target painted on the controllers display at the Denver ARTCC. The manual score sheets have been included as pages A1-A3. Data in the left column of the manual scoring sheets indicates range increments in nautical miles from the radar site to the aircraft. Each of the columns

to the right list the presence of a target as "1" and absence as a "0", for each scan of the display as the aircraft traveled from one five mile range mark to the next. If the target reaches the next range ring before the last column, as is typical of a slower aircraft, new recordings are then entered on the next row starting in the first column. Since the display at the ARTCC was not able to provide a range ring, constant communications with the site provided an indication when each range threshold was passed. Additional numbers occasionally listed in the sweep columns provide a more precise range indication. The technician at the site could more precisely track the aircraft and relay this information to the manual scorer at the Denver ARTCC via telephone.

After the plane reached the cone of silence and began its orbital flight, the function of the left hand column on page A3 was changed to indicate the azimuth of the plane relative to true north. On this page the numbers listed in the sweep columns indicate the azimuth snapshots relative to true north. Also note the tedium of writing a "1" to indicate a target was displayed eventually reduced to just recording the azimuth if a target was displayed.

The polar plots and data indicated on pages B1 through B7 and C1 through C7 were recorded directly from the CD by the local radar site manager, Stephen Lucero, and reduced using the software analysis tool PLOTCD at the Northwest Mountain Regional Office in Renton, Washington. Pages B1 through B7 contain plots and data covering the inbound flight at 57.1° true and an altitude of 15,600 feet MSL while pages C1 through C7 contain plots and data covering the orbit at 10 NMi radius and 8,000 feet MSL.

The polar plots on pages B1 and C1 graphically describe the flight profile during the investigation, while pages B2 and C2 are expanded images of the areas of interest. The following symbols are used to indicate which radar(s) had tracked the aircraft for each scan in the graphs:

- ☐ for a correlated radar and beacon return
- for a radar only return
- ☐ for a beacon only return.

Pages B3 through B7 and C3 through C7 provide numerical data for each scan of the radar and beacon. A description of the data in each column is as follows:

- SCAN** Indicates a scan number relative to when the recording was started. Note the scan number does not start at zero because the target was not being tracked. Only the flight check aircraft with ID 2224 was analyzed for this report. All others were filtered out to improve clarity.
- MSG** Indicates which radars had received an acceptable return/reply.
- FLAGS** Indicates the altitude flag was recorded.
- RNG** Indicates the range to a resolution of 1/8s of a nautical mile.
- AZ** Indicates the azimuth in Azimuth Count Pulses (ACPs) from true north where azimuth in degrees = $ACP / 4096 \times 360^\circ$.
- 3/A** Indicates the aircraft ID being recorded.

ALT Indicates the uncompensated altitude as recorded by the aircraft altimeter.
RL Indicates the Run Length (RL), or number of hits received while the target was in the main beam of the radar.
TIME Indicates the local time as programmed in the recording computer at Trinidad.
PORT Indicates the hardware recording port.
DELTA Indicates the Time between beacon messages.

PRE-FLIGHT BRIEFING

No pre-flight briefing was held with the flight check aircraft crew as they had reviewed the flight check plan sent to their operations headquarters prior to flight. Coordination with the Oklahoma FIFO, Denver ARTCC Air Traffic and airway facilities was completed prior to the start of the flight check, however. This coordination was used to brief the various elements of Air Traffic, airway facilities, flight check personnel and other interested parties in an attempt to understand the purpose of the flight check and the operational impacts and support required.

INBOUND CHECK

The flight check aircraft proceeded inbound to the Trinidad LRR at an altitude of 15,600 feet MSL over the LAMAR VORTAC at 57.1° true north. The aircraft was initially detected at a range of 133.1 nautical miles and was tracked inbound to the radar site until lost in the cone of silence at 2.04 nautical miles. As indicated in the plot on page B2 and data on pages B3-7, no unexpected jitter, drop-outs, or holes were observed that were considered significant.

ORBIT COVERAGE

The flight check aircraft then proceeded into a ten nautical mile orbit of the radar site at an altitude of 8,000 feet MSL. The orbit started at a bearing of 327° and ended at a bearing of 322°. During this time, the flight check aircraft was tracked by the ATCBI-3 system for the complete orbit. Primary tracking ceased because the MTI filters detected no radial velocity. No significant beacon false targets or ring around was noted which might indicate unusual or irregular attenuation or signal scattering from the radome support joints.

CONCLUSION

The flight check procedure was designed to place a target of known reflectivity, receptivity, and signal transmitting quality in various geometric configurations intended to provide insight into the insertion characteristics of the newly installed radome at the Trinidad, Colorado long range radar facility.

From the data collected and analyzed for this report, it has been determined the new radome exhibits negligible effects on the effectiveness of the radar systems it protects. For further copies of this report or a copy of the flight check plan, please contact Steve Walsh at (206-227-2977).

12° 11' 05" DEC

Facility (ZDV) TAD

Date 11/15/20 Aircraft Savoie

Route and Altitude

Beacon Channel

Dir Pk Power watts

Transponder power High/Low

Ant Tilt Angle

Omni Pk Pwr watts

Transponder sensitivity High/Low

Comments:

TAD- normal operation

2224- BCU ID

1 bound to TAD via LAMAR @ 15600 MSL 046° 11' 05" True
27.6°

Sweep

| Range* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--------|---|-------|-------|--------|-------|--------|------|------|---|----|----|----|----|----|----|----|----|----|----|----|
| 130.0 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | |
| 130 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| 125 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | |
| 120 | 1 | 1 | 1 | 112 | 116 | | | | | | | | | | | | | | | |
| 115 | 1 | 115.0 | 119.0 | 113.2 | 112.2 | 111.14 | | | | | | | | | | | | | | |
| 110.2 | 1 | 1 | 102 | 1 | 1 | 100.8 | 102 | | | | | | | | | | | | | |
| 104.12 | 1 | 103.6 | 1 | 101.20 | 1 | | | | | | | | | | | | | | | |
| 99.28 | 1 | 1 | 98.2 | 1 | 96.20 | 95.20 | | | | | | | | | | | | | | |
| 95.0 | 1 | 1 | 93.16 | 1 | 91.20 | 1 | | | | | | | | | | | | | | |
| 90.8 | 1 | 1 | 88.20 | 1 | 1 | 1 | | | | | | | | | | | | | | |
| 85.12 | 1 | 1 | 1 | 83.00 | 82.0 | 81.12 | | | | | | | | | | | | | | |
| 80.16 | 1 | 1 | 1 | 78.4 | 1 | 1 | | | | | | | | | | | | | | |
| 75.2 | 1 | 1 | 74.4 | 1 | 72.4 | 1 | | | | | | | | | | | | | | |
| 70.28 | 1 | 1 | 1 | 68.24 | 1 | 66.20 | 65.0 | 65.0 | | | | | | | | | | | | |
| 65.12 | 1 | 1 | 62.4 | 1 | 61.4 | 60.12 | 1 | | | | | | | | | | | | | |
| 58.24 | 1 | 1 | 57.4 | 1 | 55.4 | 1 | | | | | | | | | | | | | | |
| 54.20 | 1 | 1 | 53.4 | 1 | 1 | 1 | | | | | | | | | | | | | | |
| 50.20 | 1 | 1 | 49.0 | 1 | 1 | 46.20 | 1 | | | | | | | | | | | | | |
| 45.28 | 1 | 1 | 44.8 | 1 | 42.20 | 1 | | | | | | | | | | | | | | |
| 41.0 | 1 | 1 | 40 | 1 | 38.20 | 1 | 1 | | | | | | | | | | | | | |
| 34.16 | 1 | 1 | 1 | 32.4 | 1 | 30.16 | 1 | | | | | | | | | | | | | |
| 30.0 | 1 | 1 | 28.0 | 1 | 1 | 25.20 | 1 | | | | | | | | | | | | | |

*Range to be recorded at 5 mile intervals.

(A-1)

Page 2/3
Display

Date 11/15/94 Aircraft 28542

Transponder power - High/Low

Transponder sensitivity - High/Low

INBOUND to FD 57.2- at 1500 MSL

Sweep

* Range to be recorded at 5 min intervals

L-6

Facility ZDU TAD Date 11/15/24 Aircraft _____
Route and Altitude _____
Beacon Channel _____ Dir Pk Power _____ watts Transponder power - High/Low
Ant Tilt Angle _____ Omni Pk Pwr _____ watts Transponder sensitivity - High/Low
Comments:

7600 FT

Sweep

| Range | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--------|-----|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| 323 | 323 | | | | | | | | | | | | | | | | | | | |
| 315 | | | | | | | | | | | | | | | | | | | | |
| 310.26 | | | | | | | | | | | | | | | | | | | | |
| 304.28 | | | | | | | | | | | | | | | | | | | | |
| 294.35 | | | | | | | | | | | | | | | | | | | | |
| 282.71 | | | | | | | | | | | | | | | | | | | | |
| 268.78 | | | | | | | | | | | | | | | | | | | | |
| 258.14 | | | | | | | | | | | | | | | | | | | | |
| 222.89 | | | | | | | | | | | | | | | | | | | | |
| 187.39 | | | | | | | | | | | | | | | | | | | | |
| 151.52 | | | | | | | | | | | | | | | | | | | | |
| 122.52 | | | | | | | | | | | | | | | | | | | | |
| 76.47 | | | | | | | | | | | | | | | | | | | | |
| 39.02 | | | | | | | | | | | | | | | | | | | | |
| 5.63 | | | | | | | | | | | | | | | | | | | | |
| 322.75 | | | | | | | | | | | | | | | | | | | | |

*Range to be recorded at 5 mile intervals

A-3

XXX 01, 02, 03

RECORDED:
11/15/94

PLOTCD VERSION 68
 (c)1992 PDS

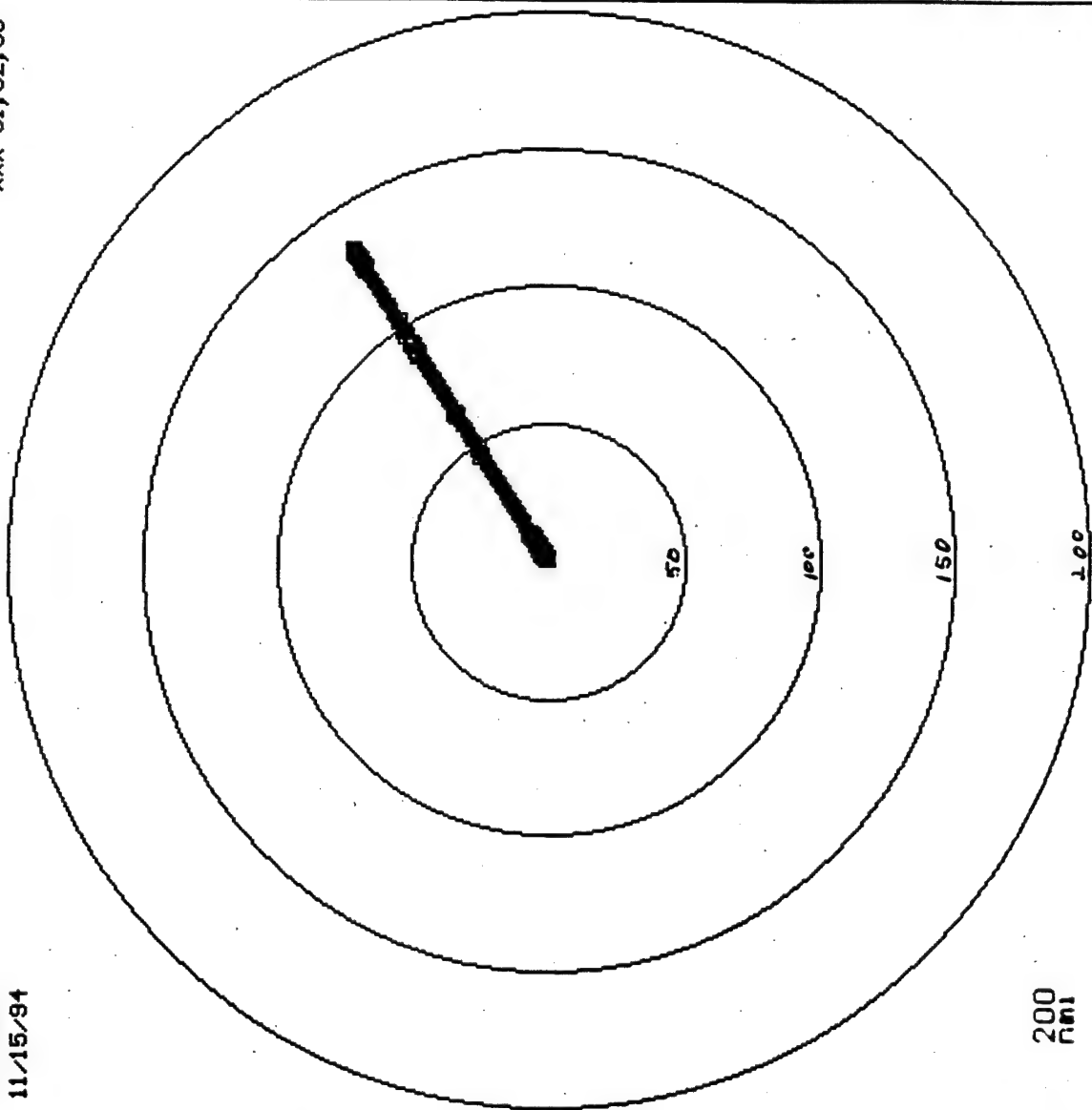
FILENAME: FC1DATA.319
SCANS: 0 THROUGH 250
Mode 3/A Code 2224
RdrBcn ☐ Enabled
Radar ☐ Enabled
Beacon ☐ Enabled
UX ☒ Disabled

Altitude = -1000 to 100000 ft.

RdrBcn count = 126
Beacon count = 38
Radar count = 0
UX count = 0

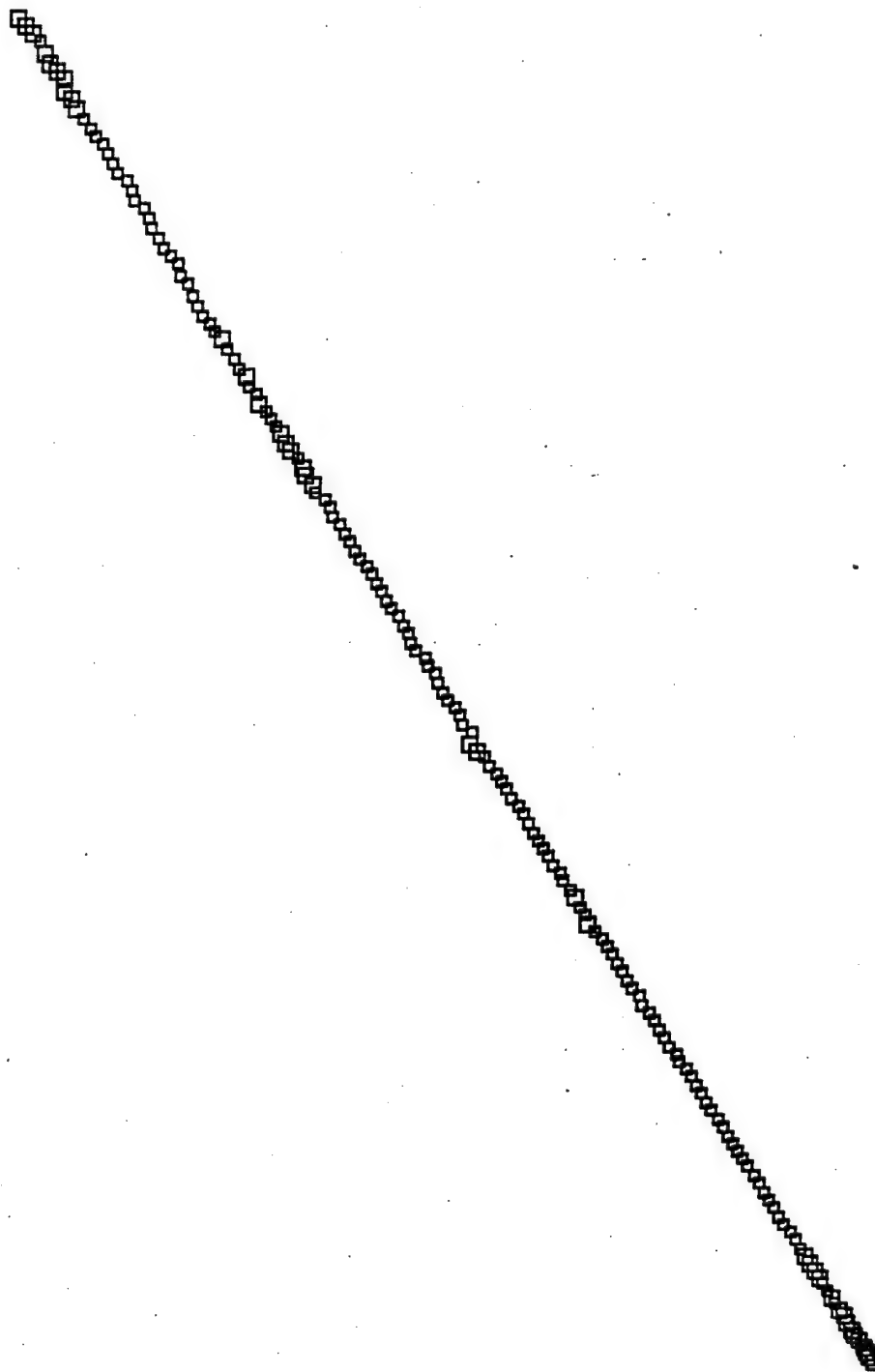
Radar = 76.8 %
Reinforced

| | | | |
|-----|--------|--------|-------|
| F1 | FILE | Alt-F1 | HELP |
| F2 | ZOOM | Alt-F2 | NOTE |
| F3 | TARGET | Alt-F3 | ID |
| F4 | SCANS | Alt-F4 | SETUP |
| F5 | RANGE | Alt-F5 | STATS |
| F9 | PRINT | Alt-F9 | STEP |
| F10 | QUIT | | |



B-1

XXX 01, 02, 03



FCIDATA.319 Scans: 0 to 250 F2-ZOOM F6-DATA F7-PR DATA F9-PR SCRIN <Esc>-ZOOM OUT

B-2

| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|---------|-------|--------|-----|------|-------|----|------------|------|-------|
| 53 | BEACON | | 133/ 7 | 650 | 2224 | 15100 | 14 | 09:57:33.4 | 03 | 0.0 |
| 54 | BEACON | 3C | 133/ 0 | 650 | 2224 | 15100 | 18 | 09:57:43.0 | 03 | 9.6 |
| 55 | BEACON | 3C | 132/ 1 | 651 | 2224 | 15100 | 18 | 09:57:52.6 | 03 | 9.6 |
| 56 | RDR/BCN | 3C | 131/ 2 | 652 | 2224 | 15100 | 20 | 09:58:02.0 | 02 | 9.4 |
| 57 | BEACON | 3C | 130/ 2 | 651 | 2224 | 15100 | 20 | 09:58:11.8 | 01 | 9.8 |
| 58 | BEACON | 3C | 129/ 3 | 651 | 2224 | 15100 | 18 | 09:58:21.3 | 01 | 9.5 |
| 59 | BEACON | 3C | 128/ 4 | 652 | 2224 | 15100 | 20 | 09:58:31.0 | 02 | 9.7 |
| 60 | BEACON | 3C | 127/ 5 | 652 | 2224 | 15100 | 24 | 09:58:40.5 | 02 | 9.5 |
| 61 | BEACON | 3C | 126/ 6 | 650 | 2224 | 15100 | 22 | 09:58:50.1 | 02 | 9.6 |
| 62 | BEACON | 3C | 125/ 7 | 651 | 2224 | 15100 | 22 | 09:58:59.7 | 03 | 9.6 |
| 63 | BEACON | 3C | 125/ 0 | 650 | 2224 | 15100 | 26 | 09:59:09.3 | 01 | 9.6 |
| 64 | RDR/BCN | 3C | 124/ 0 | 651 | 2224 | 15100 | 24 | 09:59:18.7 | 01 | 9.4 |
| 65 | RDR/BCN | 3C | 123/ 1 | 651 | 2224 | 15100 | 26 | 09:59:28.3 | 02 | 9.6 |
| 66 | RDR/BCN | 3C | 122/ 2 | 651 | 2224 | 15100 | 28 | 09:59:37.9 | 01 | 9.6 |
| 67 | RDR/BCN | 3C | 121/ 3 | 652 | 2224 | 15100 | 30 | 09:59:47.5 | 03 | 9.6 |
| 68 | RDR/BCN | 3C | 120/ 4 | 651 | 2224 | 15100 | 34 | 09:59:57.1 | 03 | 9.6 |
| 69 | RDR/BCN | 3C | 119/ 5 | 651 | 2224 | 15100 | 34 | 10:00:06.7 | 01 | 9.6 |
| 70 | RDR/BCN | 3C | 118/ 6 | 651 | 2224 | 15100 | 34 | 10:00:16.2 | 03 | 9.5 |
| 71 | RDR/BCN | 3C | 117/ 6 | 652 | 2224 | 15100 | 30 | 10:00:25.9 | 03 | 9.7 |
| 72 | RDR/BCN | 3C | 116/ 7 | 652 | 2224 | 15100 | 28 | 10:00:35.4 | 01 | 9.5 |
| 73 | RDR/BCN | 3C | 116/ 0 | 651 | 2224 | 15100 | 28 | 10:00:45.0 | 01 | 9.6 |
| 74 | RDR/BCN | 3C | 115/ 1 | 652 | 2224 | 15100 | 28 | 10:00:54.6 | 01 | 9.6 |
| 75 | RDR/BCN | 3C | 114/ 2 | 652 | 2224 | 15100 | 30 | 10:01:04.2 | 03 | 9.6 |
| 76 | RDR/BCN | 3C | 113/ 3 | 651 | 2224 | 15100 | 30 | 10:01:13.8 | 03 | 9.6 |
| 77 | RDR/BCN | 3C | 112/ 3 | 651 | 2224 | 15100 | 30 | 10:01:23.4 | 02 | 9.6 |
| 78 | RDR/BCN | 3C | 111/ 4 | 651 | 2224 | 15100 | 30 | 10:01:32.9 | 03 | 9.5 |
| 79 | RDR/BCN | 3C | 110/ 5 | 651 | 2224 | 15100 | 28 | 10:01:42.5 | 01 | 9.6 |
| 80 | RDR/BCN | 3C | 109/ 6 | 653 | 2224 | 15100 | 30 | 10:01:52.1 | 02 | 9.6 |
| 81 | RDR/BCN | 3C | 108/ 7 | 651 | 2224 | 15100 | 32 | 10:02:01.6 | 02 | 9.5 |
| 82 | RDR/BCN | 3C | 108/ 0 | 651 | 2224 | 15100 | 30 | 10:02:11.3 | 01 | 9.7 |
| 83 | RDR/BCN | 3C | 107/ 0 | 650 | 2224 | 15100 | 32 | 10:02:20.8 | 01 | 9.5 |
| 84 | RDR/BCN | 3C | 106/ 1 | 650 | 2224 | 15100 | 32 | 10:02:30.4 | 02 | 9.6 |
| 85 | RDR/BCN | 3C | 105/ 2 | 649 | 2224 | 15100 | 30 | 10:02:40.0 | 02 | 9.6 |
| 86 | RDR/BCN | 3C | 104/ 3 | 650 | 2224 | 15100 | 32 | 10:02:49.6 | 01 | 9.6 |
| 87 | RDR/BCN | 3C | 103/ 4 | 651 | 2224 | 15100 | 30 | 10:02:59.3 | 02 | 9.7 |
| 88 | BEACON | 3C | 102/ 5 | 652 | 2224 | 15100 | 30 | 10:03:08.8 | 01 | 9.5 |
| 89 | RDR/BCN | 3C | 101/ 6 | 651 | 2224 | 15100 | 28 | 10:03:18.3 | 01 | 9.5 |
| 90 | RDR/BCN | 3C | 100/ 6 | 651 | 2224 | 15100 | 30 | 10:03:27.9 | 01 | 9.6 |
| 91 | RDR/BCN | 3C | 99/ 7 | 651 | 2224 | 15100 | 30 | 10:03:37.5 | 02 | 9.6 |
| 92 | BEACON | 3C | 99/ 0 | 652 | 2224 | 15100 | 26 | 10:03:47.2 | 01 | 9.7 |
| 93 | RDR/BCN | 3C | 98/ 2 | 651 | 2224 | 15100 | 30 | 10:03:56.7 | 03 | 9.5 |
| 94 | RDR/BCN | 3C | 97/ 3 | 651 | 2224 | 15100 | 30 | 10:04:06.2 | 03 | 9.5 |
| 95 | BEACON | 3C | 96/ 5 | 650 | 2224 | 15100 | 32 | 10:04:15.9 | 01 | 9.7 |
| 96 | RDR/BCN | 3C | 95/ 7 | 651 | 2224 | 15100 | 30 | 10:04:25.3 | 02 | 9.4 |
| 97 | RDR/BCN | 3C | 95/ 0 | 651 | 2224 | 15100 | 28 | 10:04:34.9 | 02 | 9.6 |
| 98 | RDR/BCN | 3C | 94/ 2 | 651 | 2224 | 15100 | 28 | 10:04:44.6 | 01 | 9.7 |
| 99 | BEACON | 3C | 93/ 4 | 652 | 2224 | 15100 | 28 | 10:04:54.2 | 01 | 9.6 |
| 100 | BEACON | 3C | 92/ 5 | 651 | 2224 | 15100 | 28 | 10:05:03.8 | 03 | 9.6 |
| 101 | BEACON | 3C | 91/ 7 | 651 | 2224 | 15100 | 30 | 10:05:13.4 | 01 | 9.6 |
| 102 | RDR/BCN | 3C | 91/ 1 | 652 | 2224 | 15100 | 30 | 10:05:22.9 | 03 | 9.5 |
| 103 | BEACON | 3C | 90/ 2 | 652 | 2224 | 15100 | 30 | 10:05:32.6 | 02 | 9.7 |
| 104 | BEACON | 3C | 89/ 4 | 651 | 2224 | 15100 | 30 | 10:05:42.1 | 01 | 9.5 |
| 105 | BEACON | 3C | 88/ 5 | 651 | 2224 | 15100 | 30 | 10:05:51.7 | 03 | 9.6 |
| 106 | RDR/BCN | 3C | 87/ 7 | 650 | 2224 | 15100 | 30 | 10:06:01.2 | 01 | 9.5 |
| 107 | RDR/BCN | 3C | 87/ 0 | 652 | 2224 | 15100 | 30 | 10:06:10.8 | 03 | 9.6 |

B-3

| | | | | | | | | | | |
|-----|---------|-----|-------|-----|------|-------|----|------------|----|-----|
| 108 | RDR/BCN | 3C | 86/ 2 | 652 | 2224 | 15100 | 30 | 10:06:20.4 | 01 | 9.6 |
| 109 | RDR/BCN | 3C* | 85/ 3 | 651 | 2224 | 15100 | 30 | 10:06:30.0 | 03 | 9.6 |
| 110 | RDR/BCN | 3C | 84/ 5 | 652 | 2224 | 15100 | 34 | 10:06:39.6 | 03 | 9.6 |

B-4

| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|---------|-------|-------|-----|------|-------|----|------------|------|-------|
| 111 | RDR/BCN | 3C | 83/ 6 | 651 | 2224 | 15100 | 32 | 10:06:49.1 | 03 | 9.5 |
| 112 | RDR/BCN | 3C | 83/ 0 | 652 | 2224 | 15100 | 32 | 10:06:58.7 | 01 | 9.6 |
| 113 | RDR/BCN | 3C | 82/ 1 | 651 | 2224 | 15100 | 34 | 10:07:08.3 | 01 | 9.6 |
| 114 | RDR/BCN | 3C | 81/ 3 | 652 | 2224 | 15100 | 32 | 10:07:17.9 | 02 | 9.6 |
| 115 | RDR/BCN | 3C | 80/ 4 | 653 | 2224 | 15100 | 34 | 10:07:27.5 | 02 | 9.6 |
| 116 | RDR/BCN | 3C | 79/ 6 | 652 | 2224 | 15100 | 30 | 10:07:37.0 | 03 | 9.5 |
| 117 | RDR/BCN | 3C | 78/ 7 | 651 | 2224 | 15100 | 34 | 10:07:46.6 | 01 | 9.6 |
| 118 | RDR/BCN | 3C | 78/ 1 | 652 | 2224 | 15100 | 34 | 10:07:56.2 | 03 | 9.6 |
| 119 | RDR/BCN | 3C | 77/ 2 | 652 | 2224 | 15100 | 34 | 10:08:05.8 | 02 | 9.6 |
| 120 | RDR/BCN | 3C | 76/ 4 | 652 | 2224 | 15100 | 30 | 10:08:15.4 | 02 | 9.6 |
| 121 | RDR/BCN | 3C | 75/ 5 | 652 | 2224 | 15100 | 32 | 10:08:24.9 | 03 | 9.5 |
| 122 | RDR/BCN | 3C | 74/ 7 | 652 | 2224 | 15100 | 30 | 10:08:34.5 | 01 | 9.6 |
| 123 | RDR/BCN | 3C | 74/ 1 | 652 | 2224 | 15100 | 32 | 10:08:44.1 | 03 | 9.6 |
| 124 | RDR/BCN | 3C | 73/ 2 | 651 | 2224 | 15100 | 28 | 10:08:53.7 | 02 | 9.6 |
| 125 | RDR/BCN | 3C | 72/ 4 | 651 | 2224 | 15100 | 30 | 10:09:03.3 | 03 | 9.6 |
| 126 | RDR/BCN | 3C | 71/ 5 | 653 | 2224 | 15100 | 32 | 10:09:12.9 | 02 | 9.6 |
| 127 | RDR/BCN | 3C | 70/ 7 | 652 | 2224 | 15100 | 32 | 10:09:22.4 | 01 | 9.5 |
| 128 | RDR/BCN | 3C | 70/ 0 | 654 | 2224 | 15100 | 28 | 10:09:32.0 | 03 | 9.6 |
| 129 | RDR/BCN | 3C | 69/ 2 | 651 | 2224 | 15100 | 36 | 10:09:41.6 | 03 | 9.6 |
| 130 | RDR/BCN | 3C | 68/ 3 | 651 | 2224 | 15100 | 34 | 10:09:51.2 | 01 | 9.6 |
| 131 | RDR/BCN | 3C | 67/ 5 | 651 | 2224 | 15100 | 36 | 10:10:00.8 | 01 | 9.6 |
| 132 | RDR/BCN | 3C | 66/ 6 | 652 | 2224 | 15100 | 36 | 10:10:10.4 | 01 | 9.6 |
| 133 | RDR/BCN | 3C* | 66/ 0 | 652 | 2224 | 15100 | 38 | 10:10:19.9 | 01 | 9.5 |
| 134 | RDR/BCN | 3C | 65/ 2 | 651 | 2224 | 15100 | 36 | 10:10:29.5 | 03 | 9.6 |
| 135 | RDR/BCN | 3C | 64/ 3 | 653 | 2224 | 15000 | 38 | 10:10:39.1 | 03 | 9.6 |
| 136 | BEACON | 3C | 63/ 5 | 646 | 2224 | 15100 | 44 | 10:10:48.8 | 03 | 9.7 |
| 137 | BEACON | 3C | 62/ 6 | 648 | 2224 | 15100 | 40 | 10:10:58.4 | 03 | 9.6 |
| 138 | RDR/BCN | 3C | 62/ 0 | 651 | 2224 | 15100 | 38 | 10:11:07.8 | 03 | 9.4 |
| 139 | RDR/BCN | 3C | 61/ 1 | 651 | 2224 | 15100 | 38 | 10:11:17.4 | 01 | 9.6 |
| 140 | RDR/BCN | 3C | 60/ 3 | 652 | 2224 | 15100 | 38 | 10:11:27.0 | 01 | 9.6 |
| 141 | RDR/BCN | 3C | 59/ 4 | 652 | 2224 | 15100 | 36 | 10:11:36.6 | 03 | 9.6 |
| 142 | RDR/BCN | 3C | 58/ 6 | 652 | 2224 | 15100 | 38 | 10:11:46.2 | 01 | 9.6 |
| 143 | RDR/BCN | 3C | 57/ 7 | 652 | 2224 | 15100 | 38 | 10:11:55.8 | 03 | 9.6 |
| 144 | RDR/BCN | 3C | 57/ 1 | 653 | 2224 | 15100 | 36 | 10:12:05.3 | 03 | 9.5 |
| 145 | RDR/BCN | 3C | 56/ 2 | 654 | 2224 | 15100 | 36 | 10:12:14.9 | 03 | 9.6 |
| 146 | RDR/BCN | 3C | 55/ 4 | 653 | 2224 | 15100 | 38 | 10:12:24.5 | 01 | 9.6 |
| 147 | RDR/BCN | 3C | 54/ 5 | 652 | 2224 | 15100 | 40 | 10:12:34.1 | 01 | 9.6 |
| 148 | RDR/BCN | 3C | 53/ 7 | 653 | 2224 | 15100 | 36 | 10:12:43.7 | 03 | 9.6 |
| 149 | RDR/BCN | 3C | 53/ 1 | 653 | 2224 | 15100 | 36 | 10:12:53.3 | 03 | 9.6 |
| 150 | RDR/BCN | 3C | 52/ 2 | 653 | 2224 | 15100 | 36 | 10:13:02.8 | 02 | 9.5 |
| 151 | RDR/BCN | 3C | 51/ 4 | 652 | 2224 | 15100 | 34 | 10:13:12.4 | 01 | 9.6 |
| 152 | RDR/BCN | 3C | 50/ 5 | 654 | 2224 | 15100 | 36 | 10:13:22.0 | 03 | 9.6 |
| 153 | RDR/BCN | 3C | 49/ 7 | 652 | 2224 | 15100 | 38 | 10:13:31.6 | 02 | 9.6 |
| 154 | RDR/BCN | 3C | 49/ 0 | 653 | 2224 | 15100 | 36 | 10:13:41.2 | 01 | 9.6 |
| 155 | BEACON | 3C | 48/ 2 | 654 | 2224 | 15100 | 36 | 10:13:50.8 | 03 | 9.6 |
| 156 | RDR/BCN | 3C | 47/ 3 | 653 | 2224 | 15100 | 30 | 10:14:00.3 | 03 | 9.5 |
| 157 | RDR/BCN | 3C | 46/ 5 | 652 | 2224 | 15100 | 36 | 10:14:09.9 | 02 | 9.6 |
| 158 | BEACON | 3C | 45/ 7 | 649 | 2224 | 15100 | 22 | 10:14:19.6 | 02 | 9.7 |
| 159 | RDR/BCN | 3C | 45/ 0 | 652 | 2224 | 15100 | 38 | 10:14:29.1 | 03 | 9.5 |
| 160 | RDR/BCN | 3C | 44/ 2 | 653 | 2224 | 15100 | 34 | 10:14:38.7 | 03 | 9.6 |
| 161 | RDR/BCN | 3C | 43/ 3 | 653 | 2224 | 15100 | 34 | 10:14:48.2 | 02 | 9.5 |
| 162 | RDR/BCN | 3C | 42/ 5 | 653 | 2224 | 15100 | 38 | 10:14:57.8 | 03 | 9.6 |
| 163 | RDR/BCN | 3C | 41/ 6 | 652 | 2224 | 15100 | 36 | 10:15:07.4 | 01 | 9.6 |
| 164 | RDR/BCN | 3C | 41/ 0 | 652 | 2224 | 15100 | 34 | 10:15:17.0 | 01 | 9.6 |
| 165 | RDR/BCN | 3C | 40/ 1 | 653 | 2224 | 15100 | 36 | 10:15:26.6 | 03 | 9.6 |

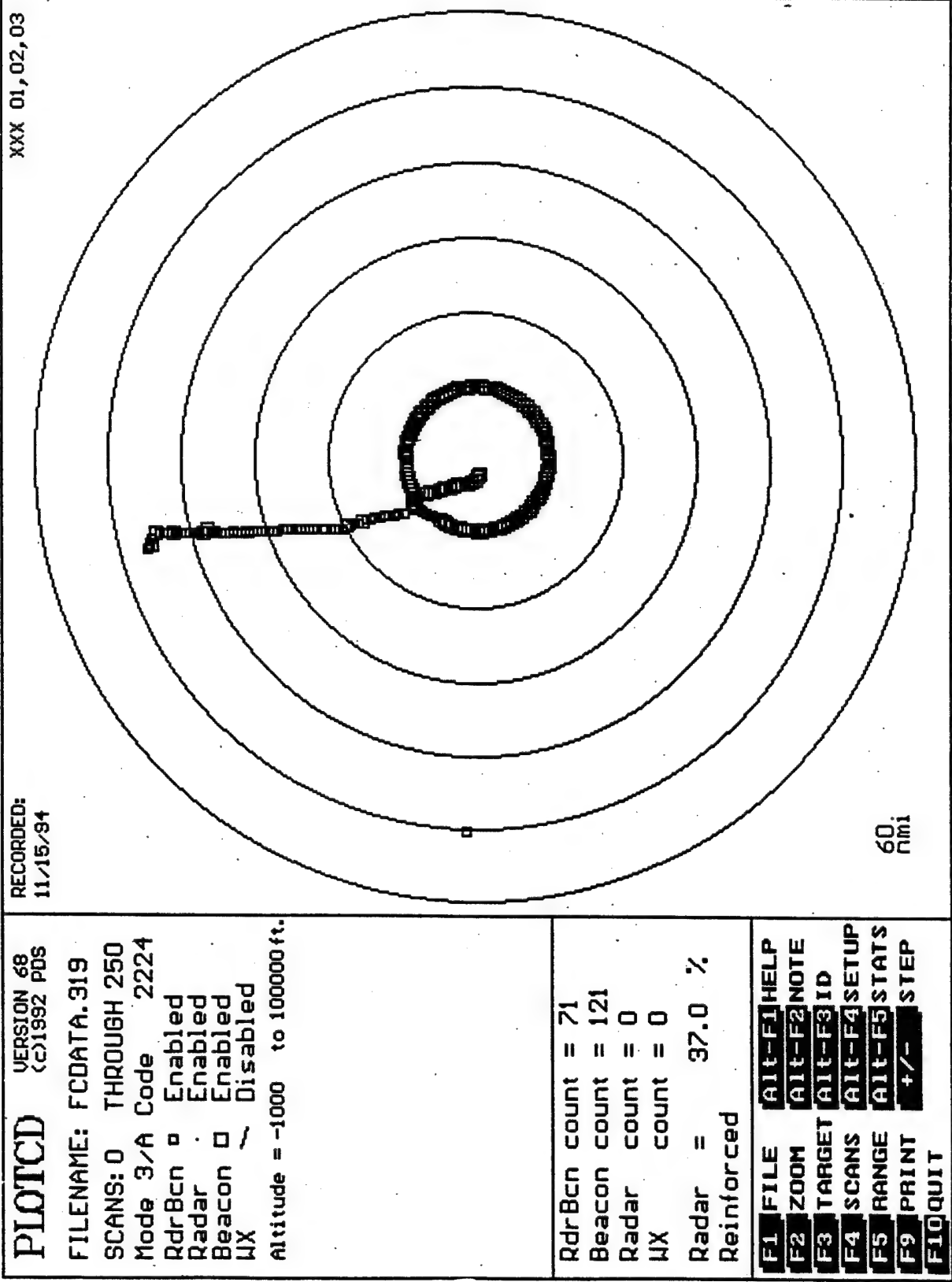
B-5

| | | | | | | | | | | |
|-----|---------|----|-------|-----|------|-------|----|------------|----|-----|
| 166 | RDR/BCN | 3C | 39/ 3 | 653 | 2224 | 15100 | 36 | 10:15:36.1 | 03 | 9.5 |
| 167 | RDR/BCN | 3C | 38/ 4 | 654 | 2224 | 15100 | 36 | 10:15:45.7 | 02 | 9.6 |
| 168 | RDR/BCN | 3C | 37/ 6 | 652 | 2224 | 15100 | 36 | 10:15:55.4 | 02 | 9.7 |

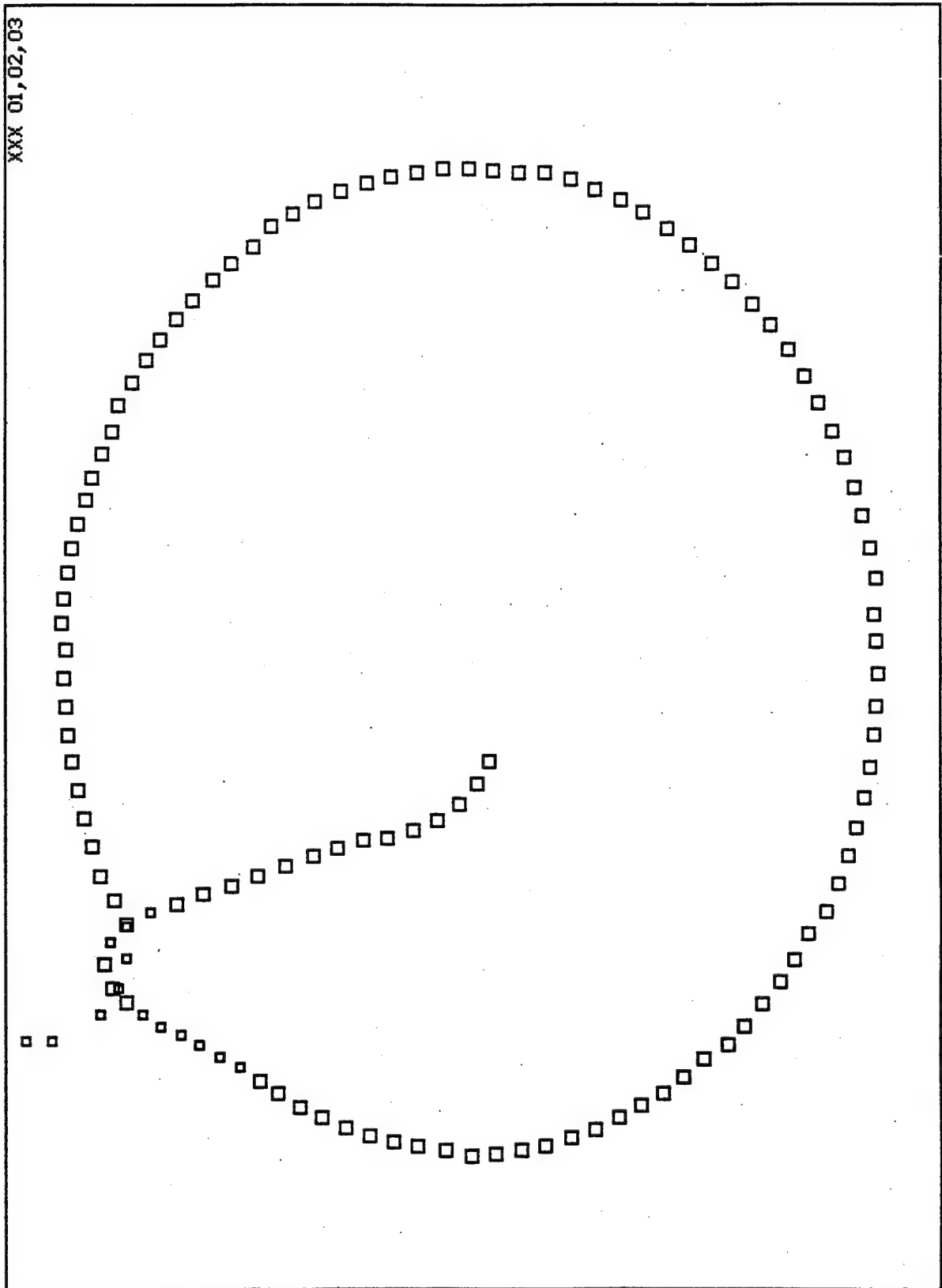
B-6

| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|---------|-------|-------|-----|------|-------|----|------------|------|-------|
| 169 | RDR/BCN | 3C | 36/ 7 | 653 | 2224 | 15100 | 36 | 10:16:04.9 | 01 | 9.5 |
| 170 | RDR/BCN | 3C | 36/ 1 | 655 | 2224 | 15100 | 32 | 10:16:14.5 | 02 | 9.6 |
| 171 | RDR/BCN | 3C | 35/ 2 | 653 | 2224 | 15100 | 36 | 10:16:24.1 | 01 | 9.6 |
| 172 | RDR/BCN | 3C | 34/ 4 | 653 | 2224 | 15100 | 38 | 10:16:33.6 | 01 | 9.5 |
| 173 | RDR/BCN | 3C | 33/ 5 | 653 | 2224 | 15100 | 38 | 10:16:43.2 | 03 | 9.6 |
| 174 | RDR/BCN | 3C | 32/ 7 | 654 | 2224 | 15100 | 34 | 10:16:52.8 | 03 | 9.6 |
| 175 | RDR/BCN | 3C | 32/ 1 | 653 | 2224 | 15100 | 36 | 10:17:02.4 | 02 | 9.6 |
| 176 | RDR/BCN | 3C | 31/ 2 | 654 | 2224 | 15100 | 36 | 10:17:12.0 | 01 | 9.6 |
| 177 | RDR/BCN | 3C | 30/ 4 | 655 | 2224 | 15100 | 34 | 10:17:21.5 | 01 | 9.5 |
| 178 | RDR/BCN | 3C | 29/ 5 | 654 | 2224 | 15100 | 34 | 10:17:31.2 | 02 | 9.7 |
| 179 | RDR/BCN | 3C | 28/ 7 | 654 | 2224 | 15100 | 36 | 10:17:40.7 | 02 | 9.5 |
| 180 | RDR/BCN | 3C | 28/ 0 | 654 | 2224 | 15100 | 34 | 10:17:50.3 | 02 | 9.6 |
| 181 | RDR/BCN | 3C | 27/ 2 | 653 | 2224 | 15100 | 36 | 10:17:59.9 | 03 | 9.6 |
| 182 | RDR/BCN | 3C | 26/ 3 | 654 | 2224 | 15100 | 34 | 10:18:09.4 | 03 | 9.5 |
| 183 | RDR/BCN | 3C | 25/ 5 | 655 | 2224 | 15100 | 36 | 10:18:19.0 | 03 | 9.6 |
| 184 | RDR/BCN | 3C | 24/ 6 | 653 | 2224 | 15100 | 36 | 10:18:28.6 | 03 | 9.6 |
| 185 | RDR/BCN | 3C | 24/ 0 | 655 | 2224 | 15100 | 36 | 10:18:38.2 | 03 | 9.6 |
| 186 | RDR/BCN | 3C | 23/ 2 | 656 | 2224 | 15100 | 36 | 10:18:47.8 | 01 | 9.6 |
| 187 | RDR/BCN | 3C | 22/ 3 | 654 | 2224 | 15100 | 36 | 10:18:57.4 | 01 | 9.6 |
| 188 | RDR/BCN | 3C | 21/ 5 | 656 | 2224 | 15100 | 36 | 10:19:06.9 | 02 | 9.5 |
| 189 | RDR/BCN | 3C | 20/ 6 | 656 | 2224 | 15100 | 36 | 10:19:16.6 | 02 | 9.7 |
| 190 | RDR/BCN | 3C | 20/ 0 | 657 | 2224 | 15100 | 36 | 10:19:26.1 | 01 | 9.5 |
| 191 | RDR/BCN | 3C | 19/ 1 | 657 | 2224 | 15100 | 38 | 10:19:35.7 | 03 | 9.6 |
| 192 | RDR/BCN | 3C | 18/ 3 | 656 | 2224 | 15200 | 36 | 10:19:45.3 | 01 | 9.6 |
| 193 | RDR/BCN | 3C | 17/ 4 | 657 | 2224 | 15200 | 36 | 10:19:54.8 | 01 | 9.5 |
| 194 | RDR/BCN | 3C | 16/ 6 | 657 | 2224 | 15200 | 36 | 10:20:04.4 | 03 | 9.6 |
| 195 | RDR/BCN | 3C | 16/ 0 | 658 | 2224 | 15200 | 36 | 10:20:13.9 | 02 | 9.5 |
| 196 | RDR/BCN | 3C | 15/ 1 | 659 | 2224 | 15200 | 36 | 10:20:23.6 | 03 | 9.7 |
| 197 | RDR/BCN | 3C | 14/ 3 | 659 | 2224 | 15200 | 36 | 10:20:33.2 | 03 | 9.6 |
| 198 | RDR/BCN | 3C | 13/ 4 | 661 | 2224 | 15200 | 34 | 10:20:42.8 | 01 | 9.6 |
| 199 | BEACON | 3C | 12/ 6 | 659 | 2224 | 15200 | 34 | 10:20:52.5 | 03 | 9.7 |
| 200 | BEACON | 3C | 12/ 0 | 660 | 2224 | 15200 | 40 | 10:21:02.0 | 01 | 9.5 |
| 201 | BEACON | 3C | 11/ 2 | 663 | 2224 | 15200 | 34 | 10:21:11.6 | 01 | 9.6 |
| 202 | BEACON | 3C | 10/ 5 | 665 | 2224 | 15200 | 26 | 10:21:21.2 | 01 | 9.6 |
| 203 | RDR/BCN | 3C | 10/ 0 | 666 | 2224 | 15200 | 42 | 10:21:30.7 | 03 | 9.5 |
| 204 | RDR/BCN | 3C | 9/ 3 | 668 | 2224 | 15200 | 42 | 10:21:40.3 | 01 | 9.6 |
| 205 | BEACON | 3C | 8/ 6 | 666 | 2224 | 15200 | 42 | 10:21:50.0 | 03 | 9.7 |
| 206 | RDR/BCN | 3C | 8/ 1 | 671 | 2224 | 15200 | 42 | 10:21:59.5 | 02 | 9.5 |
| 207 | BEACON | 3C | 7/ 4 | 672 | 2224 | 15200 | 42 | 10:22:09.1 | 01 | 9.6 |
| 208 | BEACON | 3C | 6/ 7 | 671 | 2224 | 15200 | 42 | 10:22:18.7 | 01 | 9.6 |
| 209 | BEACON | 3C | 6/ 2 | 673 | 2224 | 15200 | 36 | 10:22:28.3 | 03 | 9.6 |
| 210 | BEACON | 3C | 5/ 5 | 675 | 2224 | 15200 | 40 | 10:22:37.9 | 02 | 9.6 |
| 211 | BEACON | 3C | 5/ 1 | 680 | 2224 | 15200 | 40 | 10:22:47.5 | 02 | 9.6 |
| 212 | BEACON | 3C | 4/ 4 | 682 | 2224 | 15200 | 30 | 10:22:57.1 | 03 | 9.6 |
| 213 | BEACON | 3C | 3/ 7 | 690 | 2224 | 15200 | 30 | 10:23:06.6 | 03 | 9.5 |
| 214 | BEACON | 3C | 3/ 3 | 696 | 2224 | 15200 | 28 | 10:23:16.2 | 01 | 9.6 |
| 215 | BEACON | 3C | 2/ 7 | 705 | 2224 | 15200 | 18 | 10:23:25.9 | 03 | 9.7 |
| 216 | BEACON | 3C | 2/ 3 | 724 | 2224 | 15200 | 28 | 10:23:35.5 | 03 | 9.6 |
| 216 | BEACON | 3C | 2/ 3 | 724 | 2224 | 15200 | 28 | 10:23:35.5 | 03 | 0.0 |

(B-7)



| | |
|---|---|
| PLOTCD VERSION 68 (C)1992 PDS | FILENAME: FCDATA.319 |
| SCANS: 0 THROUGH 250 | Mode 3/A Code 2224 |
| RdrBcn <input type="checkbox"/> Enabled | Radar <input type="checkbox"/> Enabled |
| Beacon <input type="checkbox"/> Enabled | WX <input checked="" type="checkbox"/> Disabled |
| Altitude = -1000 to 100000 ft. | |
| RdrBcn count = 71 | |
| Beacon count = 121 | |
| Radar count = 0 | |
| WX count = 0 | |
| Radar = 37.0 % | |
| Reinforced | |
| F1 FILE | Alt-F1 HELP |
| F2 ZOOM | Alt-F2 NOTE |
| F3 TARGET | Alt-F3 ID |
| F4 SCANS | Alt-F4 SETUP |
| F5 RANGE | Alt-F5 STATS |
| F9 PRINT | +/- STEP |
| F10QUIT | |



FCDATA.319 Scans: 0 to 250 F2-ZOOM F6-DATA F7-PR DATA F9-PR SCRIN <Esc>-ZOOM OUT

C-2

| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|---------|-------|-------|------|------|-------|----|------------|------|-------|
| 3 | BEACON | 3C | 1/ 7 | 2845 | 2224 | 14100 | 42 | 10:24:36.8 | 03 | 0.0 |
| 4 | BEACON | 3C | 2/ 2 | 2975 | 2224 | 13600 | 24 | 10:24:46.7 | 02 | 9.9 |
| 5 | BEACON | 3C | 2/ 5 | 3097 | 2224 | 13100 | 28 | 10:24:56.5 | 01 | 9.8 |
| 6 | BEACON | 3C | 3/ 0 | 3208 | 2224 | 12800 | 32 | 10:25:06.4 | 01 | 9.9 |
| 7 | BEACON | 3C | 3/ 3 | 3311 | 2224 | 12400 | 36 | 10:25:16.2 | 02 | 9.8 |
| 8 | BEACON | 3C | 3/ 6 | 3401 | 2224 | 12000 | 42 | 10:25:26.0 | 02 | 9.8 |
| 9 | BEACON | 3C | 4/ 1 | 3476 | 2224 | 11600 | 44 | 10:25:35.8 | 01 | 9.8 |
| 10 | BEACON | 3C | 4/ 5 | 3535 | 2224 | 11100 | 36 | 10:25:45.5 | 01 | 9.7 |
| 11 | BEACON | 3C | 5/ 1 | 3580 | 2224 | 10400 | 40 | 10:25:55.1 | 01 | 9.6 |
| 12 | BEACON | 3C | 5/ 6 | 3614 | 2224 | 9800 | 42 | 10:26:04.9 | 02 | 9.8 |
| 13 | BEACON | 3C | 6/ 3 | 3644 | 2224 | 9200 | 36 | 10:26:14.5 | 03 | 9.6 |
| 14 | BEACON | 3C | 7/ 0 | 3669 | 2224 | 8700 | 36 | 10:26:24.1 | 03 | 9.6 |
| 15 | BEACON | 3C | 7/ 5 | 3691 | 2224 | 8300 | 36 | 10:26:33.8 | 01 | 9.7 |
| 16 | BEACON | 3C | 8/ 2 | 3707 | 2224 | 7900 | 36 | 10:26:43.4 | 01 | 9.6 |
| 17 | RDR/BCN | 3C | 8/ 7 | 3724 | 2224 | 7700 | 20 | 10:26:52.9 | 02 | 9.5 |
| 18 | BEACON | 3C | 9/ 4 | 3732 | 2224 | 7600 | 28 | 10:27:02.6 | 01 | 9.7 |
| 19 | RDR/BCN | 3C | 10/ 0 | 3725 | 2224 | 7600 | 24 | 10:27:12.0 | 03 | 9.4 |
| 20 | BEACON | 3C | 10/ 3 | 3706 | 2224 | 7600 | 18 | 10:27:21.7 | 02 | 9.7 |
| 21 | BEACON | 3C | 10/ 4 | 3675 | 2224 | 7600 | 26 | 10:27:31.2 | 03 | 9.5 |
| 22 | BEACON | 3C | 10/ 3 | 3648 | 2224 | 7500 | 36 | 10:27:40.7 | 03 | 9.5 |
| 23 | RDR/BCN | 3C | 10/ 2 | 3621 | 2224 | 7400 | 36 | 10:27:50.2 | 01 | 9.5 |
| 24 | RDR/BCN | 3C | 10/ 1 | 3591 | 2224 | 7400 | 36 | 10:27:59.7 | 01 | 9.5 |
| 25 | RDR/BCN | 3C | 9/ 7 | 3562 | 2224 | 7600 | 32 | 10:28:09.2 | 03 | 9.5 |
| 26 | RDR/BCN | 3C | 9/ 6 | 3530 | 2224 | 7600 | 36 | 10:28:18.7 | 01 | 9.5 |
| 27 | RDR/BCN | 3C | 9/ 5 | 3496 | 2224 | 7600 | 36 | 10:28:28.2 | 01 | 9.5 |
| 28 | RDR/BCN | 3C | 9/ 4 | 3462 | 2224 | 7600 | 28 | 10:28:37.7 | 02 | 9.5 |
| 29 | BEACON | 3C | 9/ 4 | 3424 | 2224 | 7600 | 34 | 10:28:47.3 | 02 | 9.6 |
| 30 | BEACON | 3C | 9/ 4 | 3388 | 2224 | 7600 | 34 | 10:28:56.8 | 02 | 9.5 |
| 31 | BEACON | 3C | 9/ 4 | 3349 | 2224 | 7600 | 34 | 10:29:06.2 | 02 | 9.4 |
| 32 | BEACON | 3C | 9/ 4 | 3309 | 2224 | 7600 | 34 | 10:29:15.7 | 01 | 9.5 |
| 33 | BEACON | 3C | 9/ 4 | 3269 | 2224 | 7600 | 30 | 10:29:25.2 | 03 | 9.5 |
| 34 | BEACON | 3C | 9/ 4 | 3228 | 2224 | 7600 | 34 | 10:29:34.7 | 01 | 9.5 |
| 35 | BEACON | 3C | 9/ 4 | 3189 | 2224 | 7600 | 30 | 10:29:44.2 | 01 | 9.5 |
| 36 | BEACON | 3C | 9/ 4 | 3148 | 2224 | 7600 | 30 | 10:29:53.7 | 01 | 9.5 |
| 37 | BEACON | 3C | 9/ 4 | 3103 | 2224 | 7600 | 36 | 10:30:03.2 | 01 | 9.5 |
| 38 | BEACON | 3C | 9/ 5 | 3058 | 2224 | 7600 | 36 | 10:30:12.6 | 02 | 9.4 |
| 39 | BEACON | 3C | 9/ 5 | 3020 | 2224 | 7600 | 34 | 10:30:22.1 | 02 | 9.5 |
| 40 | BEACON | 3C | 9/ 5 | 2978 | 2224 | 7600 | 36 | 10:30:31.6 | 01 | 9.5 |
| 41 | BEACON | 3C | 9/ 5 | 2937 | 2224 | 7600 | 34 | 10:30:41.1 | 02 | 9.5 |
| 42 | BEACON | 3C | 9/ 5 | 2895 | 2224 | 7600 | 36 | 10:30:50.6 | 02 | 9.5 |
| 43 | BEACON | 3C | 9/ 5 | 2854 | 2224 | 7600 | 36 | 10:31:00.1 | 03 | 9.5 |
| 44 | BEACON | 3C | 9/ 5 | 2814 | 2224 | 7600 | 34 | 10:31:09.5 | 03 | 9.4 |
| 45 | BEACON | 3C | 9/ 5 | 2773 | 2224 | 7600 | 36 | 10:31:19.0 | 02 | 9.5 |
| 46 | BEACON | 3C | 9/ 5 | 2735 | 2224 | 7600 | 30 | 10:31:28.5 | 01 | 9.5 |
| 47 | BEACON | 3C | 9/ 5 | 2694 | 2224 | 7600 | 34 | 10:31:38.0 | 02 | 9.5 |
| 48 | BEACON | 3C | 9/ 5 | 2655 | 2224 | 7600 | 34 | 10:31:47.5 | 03 | 9.5 |
| 49 | BEACON | 3C | 9/ 6 | 2614 | 2224 | 7600 | 34 | 10:31:57.0 | 03 | 9.5 |
| 50 | BEACON | 3C | 9/ 6 | 2577 | 2224 | 7600 | 30 | 10:32:06.5 | 02 | 9.5 |
| 51 | BEACON | 3C | 9/ 6 | 2536 | 2224 | 7600 | 34 | 10:32:16.0 | 02 | 9.5 |
| 52 | BEACON | 3C | 9/ 6 | 2496 | 2224 | 7600 | 32 | 10:32:25.5 | 03 | 9.5 |
| 53 | BEACON | 3C | 9/ 6 | 2458 | 2224 | 7600 | 34 | 10:32:34.9 | 03 | 9.4 |
| 54 | BEACON | 3C | 9/ 6 | 2418 | 2224 | 7600 | 36 | 10:32:44.5 | 01 | 9.6 |
| 55 | BEACON | 3C | 9/ 7 | 2378 | 2224 | 7600 | 34 | 10:32:54.0 | 02 | 9.5 |
| 56 | BEACON | 3C | 9/ 7 | 2335 | 2224 | 7600 | 28 | 10:33:03.5 | 03 | 9.5 |
| 57 | BEACON | 3C | 9/ 7 | 2297 | 2224 | 7600 | 26 | 10:33:12.9 | 01 | 9.4 |

(C-3)

| | | | | | | | | | | |
|----|--------|----|------|------|------|------|----|------------|----|------|
| 58 | BEACON | 3C | 9/ 7 | 2256 | 2224 | 7600 | 34 | 10:33:22.4 | 02 | 9.5 |
| 59 | BEACON | 3C | 9/ 7 | 2214 | 2224 | 7600 | 36 | 10:33:31.9 | 03 | 9.5, |
| 60 | BEACON | 3C | 9/ 7 | 2174 | 2224 | 7600 | 34 | 10:33:41.4 | 02 | 9.5 |

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| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|--------|-------|-------|------|------|------|----|------------|------|-------|
| 61 | BEACON | 3C | 9/ 7 | 2132 | 2224 | 7600 | 36 | 10:33:50.9 | 02 | 9.5 |
| 62 | BEACON | 3C | 9/ 7 | 2093 | 2224 | 7600 | 34 | 10:34:00.4 | 02 | 9.5 |
| 63 | BEACON | 3C | 9/ 7 | 2052 | 2224 | 7600 | 34 | 10:34:09.9 | 02 | 9.5 |
| 64 | BEACON | 3C | 9/ 7 | 2010 | 2224 | 7600 | 34 | 10:34:19.4 | 02 | 9.5 |
| 65 | BEACON | 3C | 9/ 7 | 1974 | 2224 | 7600 | 46 | 10:34:28.9 | 02 | 9.5 |
| 66 | BEACON | 3C | 10/ 0 | 1928 | 2224 | 7600 | 34 | 10:34:38.3 | 03 | 9.4 |
| 67 | BEACON | 3C | 10/ 0 | 1887 | 2224 | 7600 | 34 | 10:34:47.8 | 02 | 9.5 |
| 68 | BEACON | 3C | 10/ 0 | 1845 | 2224 | 7600 | 36 | 10:34:57.3 | 02 | 9.5 |
| 69 | BEACON | 3C | 10/ 0 | 1805 | 2224 | 7600 | 34 | 10:35:06.8 | 01 | 9.5 |
| 70 | BEACON | 3C | 10/ 0 | 1764 | 2224 | 7600 | 34 | 10:35:16.3 | 01 | 9.5 |
| 71 | BEACON | 3C | 10/ 0 | 1724 | 2224 | 7600 | 36 | 10:35:25.7 | 02 | 9.4 |
| 72 | BEACON | 3C | 10/ 0 | 1682 | 2224 | 7600 | 34 | 10:35:35.3 | 02 | 9.6 |
| 73 | BEACON | 3C | 10/ 0 | 1642 | 2224 | 7600 | 36 | 10:35:44.7 | 02 | 9.4 |
| 74 | BEACON | 3C | 10/ 0 | 1601 | 2224 | 7600 | 32 | 10:35:54.2 | 02 | 9.5 |
| 75 | BEACON | 3C | 10/ 0 | 1559 | 2224 | 7600 | 34 | 10:36:03.7 | 01 | 9.5 |
| 76 | BEACON | 3C | 10/ 0 | 1520 | 2224 | 7600 | 34 | 10:36:13.2 | 02 | 9.5 |
| 77 | BEACON | 3C | 10/ 0 | 1479 | 2224 | 7600 | 34 | 10:36:22.7 | 01 | 9.5 |
| 78 | BEACON | 3C | 10/ 0 | 1439 | 2224 | 7600 | 36 | 10:36:32.1 | 03 | 9.4 |
| 79 | BEACON | 3C | 10/ 0 | 1397 | 2224 | 7600 | 36 | 10:36:41.6 | 02 | 9.5 |
| 80 | BEACON | 3C | 10/ 0 | 1357 | 2224 | 7600 | 34 | 10:36:51.1 | 02 | 9.5 |
| 81 | BEACON | 3C | 10/ 0 | 1315 | 2224 | 7600 | 34 | 10:37:00.6 | 02 | 9.5 |
| 82 | BEACON | 3C | 10/ 0 | 1275 | 2224 | 7600 | 36 | 10:37:10.1 | 03 | 9.5 |
| 83 | BEACON | 3C | 10/ 0 | 1234 | 2224 | 7600 | 36 | 10:37:19.6 | 02 | 9.5 |
| 84 | BEACON | 3C | 10/ 0 | 1194 | 2224 | 7600 | 34 | 10:37:29.1 | 03 | 9.5 |
| 85 | BEACON | 3C | 10/ 0 | 1152 | 2224 | 7600 | 34 | 10:37:38.5 | 01 | 9.4 |
| 86 | BEACON | 3C | 9/ 7 | 1111 | 2224 | 7600 | 34 | 10:37:48.0 | 02 | 9.5 |
| 87 | BEACON | 3C | 9/ 7 | 1071 | 2224 | 7600 | 36 | 10:37:57.5 | 01 | 9.5 |
| 88 | BEACON | 3C | 9/ 7 | 1033 | 2224 | 7600 | 28 | 10:38:07.0 | 02 | 9.5 |
| 89 | BEACON | 3C | 9/ 7 | 992 | 2224 | 7600 | 24 | 10:38:16.5 | 01 | 9.5 |
| 90 | BEACON | 3C | 9/ 7 | 950 | 2224 | 7600 | 36 | 10:38:26.0 | 03 | 9.5 |
| 91 | BEACON | 3C | 9/ 7 | 909 | 2224 | 7600 | 36 | 10:38:35.5 | 01 | 9.5 |
| 92 | BEACON | 3C | 9/ 7 | 870 | 2224 | 7600 | 30 | 10:38:44.9 | 03 | 9.4 |
| 93 | BEACON | 3C | 9/ 7 | 829 | 2224 | 7600 | 34 | 10:38:54.4 | 01 | 9.5 |
| 94 | BEACON | 3C | 9/ 7 | 786 | 2224 | 7600 | 28 | 10:39:03.9 | 03 | 9.5 |
| 95 | BEACON | 3C | 9/ 7 | 749 | 2224 | 7600 | 36 | 10:39:13.4 | 02 | 9.5 |
| 96 | BEACON | 3C | 9/ 7 | 709 | 2224 | 7600 | 34 | 10:39:22.9 | 03 | 9.5 |
| 97 | BEACON | 3C | 9/ 6 | 670 | 2224 | 7600 | 34 | 10:39:32.4 | 02 | 9.5 |
| 98 | BEACON | 3C | 9/ 6 | 630 | 2224 | 7600 | 34 | 10:39:41.9 | 01 | 9.5 |
| 99 | BEACON | 3C | 9/ 6 | 593 | 2224 | 7600 | 36 | 10:39:51.4 | 02 | 9.5 |
| 100 | BEACON | 3C | 9/ 6 | 554 | 2224 | 7600 | 36 | 10:40:00.9 | 01 | 9.5 |
| 101 | BEACON | 3C | 9/ 6 | 516 | 2224 | 7600 | 34 | 10:40:10.3 | 03 | 9.4 |
| 102 | BEACON | 3C | 9/ 6 | 480 | 2224 | 7600 | 36 | 10:40:19.8 | 02 | 9.5 |
| 103 | BEACON | 3C | 9/ 6 | 444 | 2224 | 7600 | 34 | 10:40:29.3 | 01 | 9.5 |
| 104 | BEACON | 3C | 9/ 6 | 407 | 2224 | 7600 | 36 | 10:40:38.8 | 01 | 9.5 |
| 105 | BEACON | 3C | 9/ 6 | 372 | 2224 | 7600 | 36 | 10:40:48.3 | 02 | 9.5 |
| 106 | BEACON | 3C | 9/ 5 | 337 | 2224 | 7600 | 34 | 10:40:57.8 | 01 | 9.5 |
| 107 | BEACON | 3C | 9/ 5 | 302 | 2224 | 7600 | 36 | 10:41:07.3 | 01 | 9.5 |
| 108 | BEACON | 3C | 9/ 5 | 268 | 2224 | 7600 | 36 | 10:41:16.9 | 02 | 9.6 |
| 109 | BEACON | 3C | 9/ 5 | 234 | 2224 | 7600 | 36 | 10:41:26.4 | 02 | 9.5 |
| 110 | BEACON | 3C | 9/ 5 | 200 | 2224 | 7600 | 36 | 10:41:35.9 | 03 | 9.5 |
| 111 | BEACON | 3C | 9/ 5 | 166 | 2224 | 7600 | 36 | 10:41:45.4 | 02 | 9.5 |
| 112 | BEACON | 3C | 9/ 5 | 132 | 2224 | 7600 | 36 | 10:41:54.9 | 03 | 9.5 |
| 113 | BEACON | 3C | 9/ 5 | 98 | 2224 | 7600 | 36 | 10:42:04.4 | 03 | 9.5 |
| 114 | BEACON | 3C | 9/ 5 | 64 | 2224 | 7600 | 36 | 10:42:13.9 | 01 | 9.5 |
| 115 | BEACON | 3C | 9/ 4 | 28 | 2224 | 7600 | 36 | 10:42:23.3 | 02 | 9.4 |

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| | | | | | | | | | | |
|-----|--------|----|------|------|------|------|----|------------|----|-----|
| 115 | BEACON | 3C | 9/ 4 | 4086 | 2224 | 7600 | 34 | 10:42:32.9 | 02 | 9.6 |
| 116 | BEACON | 3C | 9/ 4 | 4049 | 2224 | 7600 | 32 | 10:42:42.3 | 01 | 9.4 |
| 117 | BEACON | 3C | 9/ 4 | 4010 | 2224 | 7600 | 36 | 10:42:51.9 | 01 | 9.6 |

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CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

| SCAN | MSG | FLAGS | RNG | AZ | 3/A | ALT | RL | TIME | PORT | DELTA |
|------|---------|-------|-------|------|------|------|----|------------|------|-------|
| 118 | BEACON | 3C | 9/ 4 | 3973 | 2224 | 7600 | 34 | 10:43:01.3 | 02 | 9.4 |
| 119 | BEACON | 3C | 9/ 4 | 3933 | 2224 | 7600 | 32 | 10:43:10.9 | 01 | 9.6 |
| 120 | BEACON | 3C | 9/ 4 | 3893 | 2224 | 7600 | 34 | 10:43:20.3 | 01 | 9.4 |
| 121 | BEACON | 3C | 9/ 4 | 3853 | 2224 | 7600 | 30 | 10:43:29.8 | 02 | 9.5 |
| 122 | BEACON | 3C* | 9/ 4 | 3811 | 2224 | 7600 | 36 | 10:43:39.3 | 03 | 9.5 |
| 123 | BEACON | 3C | 9/ 4 | 3770 | 2224 | 7600 | 36 | 10:43:48.8 | 01 | 9.5 |
| 124 | RDR/BCN | 3C | 9/ 4 | 3729 | 2224 | 7600 | 36 | 10:43:58.2 | 02 | 9.4 |
| 125 | RDR/BCN | 3C | 9/ 7 | 3694 | 2224 | 7600 | 32 | 10:44:07.7 | 02 | 9.5 |
| 126 | RDR/BCN | 3C | 10/ 3 | 3670 | 2224 | 7600 | 36 | 10:44:17.2 | 03 | 9.5 |
| 127 | RDR/BCN | 3C | 11/ 0 | 3661 | 2224 | 7600 | 34 | 10:44:26.7 | 03 | 9.5 |
| 129 | RDR/BCN | 3C | 12/ 2 | 3678 | 2224 | 7600 | 32 | 10:44:46.0 | 02 | 19.3 |
| 130 | RDR/BCN | 3C | 12/ 6 | 3696 | 2224 | 7600 | 30 | 10:44:55.6 | 01 | 9.6 |

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